United States Environmental Protection Agency
REGION 2 New Jersey, New York, Puerto Rico & U S. Virgin Islands

WORLD TRADE CENTER BACKGROUND STUDY REPORT

INTERIM FINAL

April 2003

Prepared for:
United States Federal Emergency Management Agency
IAG No.: EMW-2002-IA-0127

Prepared by:
United States Environmental Protection Agency, Region 2
New York City Response and Recovery Operations
290 Broadway
New York, NY 10007-1866

Approved by:
Kathleen C. Callahan
Assistant Regional Administrator
New York City Response and Recovery Operations

Table of Contents

FIGURES

TABLES

ATTACHMENTS

ACKNOWLEDGMENTS

EPA is grateful for the generous contribution of the residents of Manhattan who provided access to EPA to sample their dwelling units, and of the building owners who provided access to the common space areas used in this Study.

This project was designed and implemented by EPA with the support of the Indoor Air Work Group of EPA's Indoor Air Task Force. The work group organizations directly involved in the development of the project included the New York City Department of Environmental Protection; New York City Department of Health and Mental Hygiene; New York City Mayor's Office of Environmental Coordination; New York City Office of Emergency Management, New York State Department of Health, Agency for Toxic Substances and Disease Registry, Occupation Safety and Health Administration, EPA's Office of Solid Waste and Emergency Response and EPA Region 2.

EPA acknowledges the assistance of New York City's Housing and Preservation Department for its assistance in identifying Study locations.

Note:
This interim final report is a working document that will be subject to further Agency and third- party review. EPA intends to excerpt, and possibly expand, portions of this report for inclusion in manuscripts that will be submitted to scientific journals for review and consideration for publishing.

EXECUTIVE SUMMARY

The United States Environmental Protection Agency (EPA) responded to the September 11, 2001 attack upon the World Trade Center in conjunction with the President's declaration of a national disaster The Federal Emergency Management Agency (FEMA), as the federal coordinating office in the disaster, issued mission assignments to EPA in the areas of cleaning dust/debris from the streets of lower Manhattan, sampling the ambient environment (air and dust samples), providing washing stations for personnel working at the WTC response and recovery site as well as equipment and dust/debris being removed from the site, and disposal of hazardous materials found at the WTC site.

Residents of lower Manhattan began to raise their concerns about the safety and reliability of cleaning methods to remove dust and debris from their residential units and building facades. Traditional FEMA support programs were available. Yet due to the unprecedented nature of the disaster and on-going concerns, residents continued to request additional assistance After evaluating the concerns related to indoor impacts of dust and debris and fire related particle deposition, EPA Administrator Christine Todd Whitman formed an Interagency Indoor Air Task Force. This group included representatives from the following agencies. the regional and national office of the EPA, FEMA, the New York City Department of Health and Mental Hygiene (NYCDOHMH), the New York City Department of Environmental Protection (NYCDEP), the New York State Department of Environmental Conservation(NYSDEC), the New York State Department of Health (NYSDOH) the Occupational Safety and Health Agency (OSHA), and the Agency for Toxic Substances and Disease Registry (ATSDR). The group recommended various issues that could be addressed. Thus, in May 2001, EPA, FEMA and NYC announced a voluntary cleanup program for residential units, that would run in parallel to several other efforts to address the concerns of lower Manhattan residents regarding the potential risks from exposure to residual WTC dust and debris These efforts were funded by FEMA through interagency agreements with EPA and NYC and include:

- identification of the Contaminants of Potential Concern (COPCs)
- a background study of the COPCs in upper Manhattan (Background Study)
- inspection and cleaning of building exteriors in lower Manhattan
- Indoor Air Residential Assistance - WTC Dust Cleanup Program
- cleaning of unoccupied, uncleaned buildings, and
- a study of cleaning techniques in an unoccupied building adjacent to the WTC site that was directly impacted by the WTC collapse (WTC

Residential Confirmation Cleaning Study)

These efforts have been conducted simultaneously to ensure that residents are provided the opportunity to have any WTC residual material removed from their units as quickly as possible.

This report presents the results of the WTC Background Study conducted by EPA Results from this Study cannot account for the variability with indoor environments in general (i.e., cross contamination from outdoors to indoors, way of life and level of cleanliness). The measurements are limited to each specific apartment or common area sampled at that specific time the samples were collected.

Project Objectives / Overview

The objective of this Background Study was to determine and/or estimate indoor baseline levels or background concentrations for the presence of specific contaminants related to building materials and combustion byproducts that may be released when building materials are burned during a fire. The background concentrations derived from this Study will be used to supplement the health-based benchmarks established in the "World Trade Center Indoor Air Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks" document and were identified as a potential source of alternate cleanup values if the health-based benchmarks were not able to be achieved The selected Contaminants of Potential Concern (COPC) includes asbestos, lead, dioxins, polycyclic aromatic hydrocarbons (PAHs), fibrous glass and minerals including crystalline silica (i.e., α-quartz, cristobalite, tridymite), calcite, gypsum, and portlandite.

The number of buildings, residences and common spaces samples were determined by what could practically be achieved to avoid impeding the project. The geographical area for the Background Study (78th Street and North) was selected based on preliminary modeling of meteorological data on September 11, 2001 and shortly thereafter. The modeling was performed by EPA's Office of Research and Development The distance of buildings sampled in the Study with respect to the WTC site ranges from 8 to 19 kilometers (5 to 12 miles).

Sampling was conducted in fourteen residential buildings not impacted by the airborne dust plume which emanated from the WTC site. When possible, samples were collected from two residential units and from one common area, such as the lobby, hallway, stairwell, or building laundry facility, in each building. In total EPA sampled twenty-five residential units and nine common areas within the fourteen buildings. Results of the Background Study are discussed in general terms and are not specific to the units sampled.

Data Assessment

The analytical data for each sample collected were evaluated for individual apartments and cumulatively in data sets (e.g., asbestos wipe sample data for residential dwellings, common spaces and a combined data set for residential and common spaces) to derive a background concentration that is representative for Manhattan.

The evaluation for individual apartments compared the reported results for each sample to the health-based criteria developed in the "World Trade Center Indoor Air Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks" report. The analytical data was presented in tabular format for each apartment with text that explains the reported results. Any detected concentration that exceeded the health-based benchmarks were discussed in detail in writing and orally when requested by owner.

Cumulatively, the data were statistically evaluated in this report to provide a mean, standard deviation, minimum and maximum. For each analyte and sample media, a concentration representative of background for Manhattan has been calculated (see table below) These background concentrations will be used to supplement the health-based benchmarks established in the "World Trade Center Indoor Air Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks" report and may be used as an alternative cleanup value if the health-based benchmark cannot be achieved.

Background concentrations that were denved based on the analytical results from the samples collected in this study. The concentrations listed in the table represent the 95% upper confidence limit (UCL) on the anthmetic mean.

Compound	Air	Settled Dust		
		Bulk Dust	Porous Surface	Hard Surface
Asbestos		n/a (<1%)		6,192 s/cm^{2R}
Asbestos - PCM	0.0023 s/cc^{R}			
Asbestos - TEM AHERA	0.00024 s/cc^{R}			
Asbestos - TEM PCMe	0 00024 s/cc$^{R/T}$			
MMVF	0 00006 s/cc$^{R/T}$	n/a (<1%)		52 s/cm^{2T}
Lead	0.03 µg/m^{3T}	186 mg/kg^{R}	1.98 µg/ft^{2T}	1.78 µg/ft^{2R}
Dioxin				0.693 ng/m^{2T}
PAH				n/a (<290 µg/m^{2})
Alpha-quartz (w/o max. value)	61.9 µg/m^{3R} (7 8 µg/m^{3R})	3.66 %^{R}		79.6 µg/ft^{2R}
Calcite	*9 3 µg/m^{3T}*	3.41 %^{R}		132.3 µg/ft^{2T}
Cnstobalite	*9.3 µg/m^{3T}*	*4 69 %^{R}*		103.7 µg/ft^{2T}
Gypsum	*9.3 µg/m^{3T}*	2.33 %^{R}		*49 9 µg/ft^{2T}*
Portlandite	*9.3 µg/m^{3T}*	*4.69 %^{R}*		*99 8 µg/ft^{2T}*
Tndymite	*9 3 µg/m^{3T}*	*4 69 %^{R}*		*99 8 µg/ft^{2T}*
Total Dust				14.4 mg/ft^{2R}

n/a - indicates that a upper confidence limit could not be calculated, value in parenthesis indicates that the value is less than the detection limit
italics - indicates a theoretical UCL due to all data being below the detection limit
T - indicates the total data set was used
R - indicates only the residential data set was used

Conclusions

In summary, the data collected from this Study, in which 1158 samples were collected, provided calculated estimates of background concentrations for compounds that were identified as COPCs related to the World Trade Center collapse. The estimates were shown to be consistent with other background studies and historical data, where comparison data were available (see table below). These estimates also provide a upper-bound point estimate that can be used as a background concentration for the COPC report.

Comparison of estimated background values from this study to background or historical values reported in the scientific literature for select compounds.

Compound	Estimated Background UCL Value	Historical/Literature Value
Asbestos - PCMe	0 00024 s/cc	0.00022 s/cc[1]
MMVF - air	0.00006 s/cc	≤0.0001 f/cc[2]
Lead - air	0.03 $\mu g/m^3$	0.02 $\mu g/m^3$[3]
Lead - wipe floors	3.91 $\mu g/ft^2$	3.45 $\mu g/ft^2$[4]
Dioxin - wipe	0 693 ng/m^2	0.67 ng/m^2[5]

(1) Consumer Product Safety Commission Study 1987

(2) ATSDR 2002

(3) Calculated value from EPA historic ambient air lead data

(4) HUD 2001

(5) Christmann. 1989

In addition, these data may provide a source to help address data gaps in scientific literature on background concentrations of building-related materials and combustion byproducts caused by building fires.

1.0 INTRODUCTION

A Background Study of the Contaminants of Potential Concern (COPCs) in upper Manhattan was conducted in parallel to several other efforts to address the concerns of lower Manhattan residents regarding the potential risks from exposure to residual WTC dust and debris These efforts were funded by FEMA through agreements with EPA and the City of New York (NYC).

While there are background reference levels for a few indoor air pollutants, comprehensive reference levels (i.e , normative concentrations) for typical residences do not exist for several reasons. In contrast to the situation for many outdoor air pollutants which have been routinely monitored for decades because of legislative mandates, no such legislation exists for indoor air pollutants.

Indoor monitoring has been generally limited because of its cost, the difficulty of obtaining access to residences due to privacy issues as well as the noise and inconvenience of sampling equipment and monitoring instrumentation. The size of a nationally representative monitoring network for residences could also be large and therefore require costly and complex studies because of the need to capture variability due to regional differences in housing construction, differences in residential types (e.g., apartments vs. single-family detached houses), seasonal differences in operation of the residence (e.g., heating vs. air conditioning), differences in human activities (e.g., smoking, cleaning methods...) occupant demographics and density, age of housing and related housing maintenance practices (e g., use of lead-based paint). In summary, useful reference levels for air pollutants or contaminants indoors typically do not exist.

2.0 BACKGROUND AND PROJECT DESCRIPTION

2.1 Background

In June 2002, EPA entered into an agreement with FEMA in order to continue to assess the impacts of possible contamination from WTC related dust in indoor residential environments. As part of this assessment, EPA needed to identify what levels of pollutants existed in indoor residential environments in New York City prior to September 11, 2001 To accomplish this, EPA developed and implemented a plan for sampling and analyzing the dust present in residential buildings located in upper Manhattan that were not affected by the collapse of the WTC from which to infer contamination levels in downtown residential building prior to September 11, 2001.

2.2 Purpose/Objective

The objective of the Background Study was to determine indoor baseline levels or background concentrations for the presence of specific contaminants related to materials used during the construction of buildings, materials that are typically found within occupied buildings and any combustion byproducts caused by fires.

The background concentrations derived from this Study will be used to supplement the health-based benchmarks established in the "World Trade Center Indoor Air Assessment Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks" document and were identified as a potential source of alternate cleanup values if the health-based benchmarks were not able to be achieved.

The selected COPCs include asbestos in air[1] by phase contrast microscopy equivalent (PCMe), phase contrast microscopy (PCM) and transmission electron microscopy (TEM) Asbestos Hazard Emergency Response Act (AHERA)[2], asbestos in settled dust, lead in air and settled dust, dioxins in settled dust, polycyclic aromatic hydrocarbons (PAHs) in settled dust, fibrous glass and minerals including alpha-quartz, cristobalite and tridymite, hereinafter referred to as crystalline silica, and other mineral dusts including calcite, gypsum, and portlandite in both air and settled dust. These contaminants are discussed in detail in the peer review draft report "World Trade Center Indoor Air Assessment. Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks" provided as Attachment A.

2.3 Project Description

Sampling was conducted in fourteen residential Manhattan buildings not impacted by the airborne dust plume that emanated from the WTC site.

When possible, samples were collected from two residential units and from one common area, such as the lobby, hallway, stairwell, or shared laundry facility in each building. In total, EPA sampled twenty-five residential units and nine common areas within the fourteen buildings Results of the Study are discussed in general terms and are not specific to the units sampled. In accordance with the agreement for Consent for Access for Environmental Sampling for the WTC Background Study, the addresses of the buildings and apartments, including the identity of the volunteers, will remain confidential.

---

[1] The asbestos air samples were collected according to NIOSH 7400 (PCM) The sample filters were analyzed using a modified AHERA method Although the total TEM (AHERA) fiber count was recorded, a separate PCMe count was recorded by modifying the AHERA method to count only fibers greater than 5µm (micrometer) It is this modified AHERA PCMe fiber count that was the basis of the asbestos test results and health based benchmarks

[2] The EPA regulates asbestos contaminated materials (ACMs) in schools via the Asbestos Hazard Emergency Response Act (AHERA) of 1986 The AHERA schools rule requires all public school districts and private schools to inspect all school buildings for ACMs; to develop plans to manage asbestos in schools; and to carry out the plans in a timely fashion The rule also provides an opportunity for parents, teachers, and other school employees to become familiar with and involved in their school's asbestos management programs

2.4 Project Team/Responsibilities

EPA Region 2 staff provided overall management and oversight of the project, identified participant buildings, obtained access to participant buildings and implemented the field sampling portion of the project with the assistance of EPA's contractor, TRC Solutions Inc. (TRC). All communication regarding site work activities, work scheduling, difficulties encountered, deviations from the QAPP/sampling plan, and project progress was addressed by the EPA Project Officer on a daily basis. TRC provided deliverables and services associated with the sampling operations for this project.

2.5 Data Usage

The data generated from this Study were used to establish baseline information on residential contaminant levels found in typical NYC dwellings.

The analytical data collected were evaluated first for individual apartments and common areas and second, cumulatively, which consisted of combining data sets for residential dwellings and common areas (i.e., asbestos wipe sample data for residential dwellings, common areas and a combined data set for residential and common spaces) to derive background concentrations representative for Manhattan.

The confidential evaluation prepared for individual apartments compared the reported results for each sample to the health-based benchmarks developed in the peer review draft of the "World Trade Center Indoor Air Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks" document. The analytical data for each analyte were presented in tabular format for each apartment with text that explains the reported results Any sampling that resulted in detections exceeding the health-based benchmarks was discussed in a detailed letter and orally when requested by the resident or owner.

Cumulatively, the data were statistically evaluated to provide descriptive statistics for each analyte and sample matrix. For each analyte, a recommended concentration that is representative of background concentrations under a given set of assumptions, for upper Manhattan, is discussed in Section 6.0 and presented in Table 8-1.

Results from this Study cannot account for the variability with indoor environments in general (e.g., cross contamination from outdoor environments to indoor environments, way of life, and level of cleanliness). The measurements are limited to each specific apartment or common area sampled at that specific time the samples were collected The selection of sample point locations within each unit were decided in the field, on a case-by-case basis and do not represent the entire apartment or common area sampled

3.0 SAMPLING APPROACH/RATIONALE

3.1 Selection of Sampling Area Location

The geographical area (Figure 1) for the Background Study (78th Street and North) was selected based on preliminary modeling of meteorological data on September 11, 2001 and shortly thereafter. The modeling was performed by EPA's Office of Research and Development (Huber, 2003). This geographical area is an area well north of the portion of Manhattan that may have been affected by the deposition of particulate matter from the collapse of the WTC The distance of buildings sampled in the Study with respect to the WTC site ranges from 8 to 19 kilometers (5 to 12 miles).

The modeling produced isopleth plots which present the dilution of the particulate emissions from the WTC site. These plots indicate that the plume was dispersed and diluted, with the concentration of particulate matter ranging from 1,000 to 10,000 times less than at the WTC site as one moves away from the WTC site in a northeast direction. These isopleths are based on how much the plume was dispersed and diluted by weather conditions and are not based on the amount of emissions from the WTC site.

3.2 Selection of Building Types and Obtaining Access

EPA and other members of the Indoor Air Working Group selected the building types designated for this Study. This Study attempted to focus on sampling sites that are similar to the downtown residential housing stock. This stock included: post-1920 non-doorman mid-rise apartments, high-rise condominiums, high-rise co-operatives, and turn-of-the-century tenements. Downtown residential lofts could not be represented in the Study, since lofts located uptown are designated for commercial use only.

In order to solicit volunteer participants from the targeted building types, a list of buildings matching the housing stock described above was provided to EPA and the NYCDOHMH by the New York City Department of Housing Preservation and Development (NYCHPD).

Initially, the task of obtaining access to buildings that would be included in the Study was the responsibility of NYCDOHMH. During the month of June, 2002 EPA assumed the responsibility for obtaining building access. EPA staff exhausted the list provided by the NYCHPD. Due to the lack of willing participants on this list, the difficulty with obtaining access, and time constraints under the Inter-Agency Agreements (IAA), EPA initiated cold calling and essentially door to door solicitation in order to solicit volunteers and gain access to buildings for participation in the Study. Therefore, not all of the buildings sampled as part of the Study were obtained from the list provided. Any building willing to participate in the Study was considered for sampling until fourteen buildings were obtained This is a deviation from the initial sampling plan regarding representation of the diverse housing stock mentioned above. The buildings sampled were constructed roughly between 1892 and 1981.

EPA began the task of obtaining access to building common areas and residential units on June 14, 2002 and continued through September 23, 2002. As access agreements were signed and returned from volunteer participants, appointments were scheduled for sampling of the building. Sample collection activities were completed on September 25, 2002.

3.3 Selection Criteria for Number of Buildings, Residences and Common Space Sampled

The number of buildings, residences and common spaces samples were determined by what could practically be achieved to avoid impeding the project. There were no formal criteria established for selecting the number of buildings to be incorporated into the study or the number of residential dwellings and common spaces to be sampled within each building due to the difficulty in obtaining access and time constraints for conducting the Study.

The objective of the Study was to collect samples from at least three sites within each building: two or more residential units and one of the building common spaces. For the most part this objective was met, however in three instances only one common space and one apartment were sampled per building and in five buildings access was obtained to sample two residential units per building. Access could not be obtained to sample the common spaces of these five buildings.

3.4 Selection of Contaminants of Potential Concern

Under the auspices of the EPA's Interagency Indoor Air Task Force, a committee was formed to identify the COPCs and associated health-based benchmarks for the Indoor Air Residential Assistance - WTC Dust Cleanup Program This committee drafted the "World Trade Center Indoor Air Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks" report that was peer reviewed on October 21-22, 2002. This report is currently being revised for finalization.

Among other purposes, this report identified the selection of contaminants for monitoring in the WTC Background Study and provided a measure of cleaning effectiveness by establishing health-based benchmarks and clean-up goals for indoor air and settled dust As such, the COPCs identified for inclusion in the Study reflect those contaminants cited in the peer review draft of the aforementioned report.

The development of the COPC report began with an assessment of the indoor environment by reviewing historical information on hazardous substances that have been associated with building fires and collapses. Many compounds, including combustion byproducts such as dioxins and PAHs were identified, along with building materials such as asbestos and fibrous glass. In addition, WTC ambient air, indoor air, and indoor/outdoor bulk dust monitoring data were reviewed. Data sources included EPA's ambient air and bulk dust/debris monitoring program www.epa.gov/wtc, OSHA's air and dust monitoring data and the NYCDOHMH/ATSDR indoor air pilot program (NYCDOHMH 2002). A concerted effort also was made by the COPC committee to identify and review additional sources of WTC related data from other governmental agencies (e g., U.S Geological Survey, NYC Board of Education), academic institutions, environmental organizations, and the private sector

A semi-quantitative screening process was performed on the collected sampling data, referenced above. Based on frequency-of-detection, concentration and inherent toxicity, contaminants that exceeded health-based screening levels for the ambient air were identified. Dioxin and PAHs were added to the COPC list by this process. In addition, building constituents with carcinogenic (asbestos) or irritant effects (fibrous glass, crystalline silica) that were consistently found in bulk and indoor dust samples were identified as COPCs (NYCDOHMH 2002). Finally, lead was included based on a comparison of sampling data with existing regulatory standards. Collectively, the resulting group of contaminants (asbestos, lead, dioxin, PAHs, fibrous glass and crystalline silica) are called "contaminants of potential concern" or COPCs in this report.

4.0 SAMPLING METHODOLOGY

Once building access was obtained and sampling scheduled, air and settled dust samples were collected from each of the fourteen buildings and shipped to the laboratories for analysis. All samples were collected and analyzed in accordance with the approved Quality Assurance Project Plan (QAPP) for the WTC Background Study, dated August 2002. The procedures used for sample collection, analysis, data validation, data management and evaluation are described in or provided as an attachment to the approved QAPP which will be furnished upon request.

4.1 Sampling Procedures

Samples were collected from twenty five residential units and 9 common spaces (i e., seven basement laundry rooms and two hallways). Sampling consisted of: indoor air samples of airborne fibers and particulate matter; microvacuum samples of settled dust on carpeting, area rugs, upholstered fabric furniture and/or drapery; wipe samples of settled dust from ceilings, walls, bare floors, counter tops or table tops; and bulk dust samples from window air conditioner filters. All samples were collected from areas routinely used and occupied by residents, such as, living rooms or bedrooms and in common areas, such as, entrance hallways or basement laundry rooms.

A summary of the sample collection and analytical procedures used are provided in Table 4-1 of this report. The following subsections provide brief descriptions of the sampling procedures to place the subsequent discussion of results in context.

4.1.1 Indoor Air Sample Collection

Airborne fibers and particulate matter were collected by drawing a known volume of air through a filter membrane cassette following the procedures specified in Table 4-1. The equipment used for the collection of air samples is provided in Section 4.2 of this report.

When available and permitted by the resident or building manager, some of the air sampling was conducted employing the use of oscillating fans and/or operating the window air conditioning units. How the air conditioning units were utilized during sampling depended upon the unit's features. For example, some units had the option to recirculate interior air or use outside air. When this option was available, the unit was set to recirculate interior room air. Other units did not have this option. The intended purpose for the use of fans or window air conditioners was to simulate typical household activity within each unit.

The collection of air samples did not employ the use of aggressive techniques due to the risk of dust exposure to the residents or persons in each unit during the sampling activities. Aggressive sampling techniques employ the use of electric leaf blowers with a maximum velocity ranging from 140 miles per hour (mph) to 225 mph, and maximum air volumes ranging from 78 cubic feet per minute (cfm) to 425 cfm in order to agitate dust into the air. The dust then remains suspended in air by using fans. The aggressive techniques do not simulate "normal" household activity or living conditions. However, as the goal of the Study was to estimate background concentrations under typical conditions, the use of non-aggressive sampling techniques is more representative of typical household activity and living conditions.

4.1.2 Microvacuum Sample Collection

Samples of settled dust were collected from porous surfaces using microvacuum techniques and analyzed for asbestos and lead. Porous surfaces included carpet, area rugs, upholstered couches, chairs, ottomans and in some cases drapery when furniture and/or carpet were not available.

The standard test method used for the collection of asbestos microvacuum samples is referenced in Table 4-1. This method describes the procedures for collecting non-airborne dust samples. It is stated in sub-section 1.2.1 of the ASTM Standard D 5755-95 that "The collection efficiency of this technique is unknown and will vary among substrates Properties influencing collection efficiency include surface texture, adhesiveness, electrostatic properties and other factors." Due to the limitation of the microvacuum sample collection method for asbestos, the intended use of the method was to determine only the presence or absence of asbestos contaminants.

For the purpose of this Study, lead dust samples were collected using microvacuum techniques for the determination of lead on a loading basis (microgram of lead per area sampled). As stated in section 1.3 of the ASTM Standard E 1973-99, "Due to a number of physical factors inherent in the vacuum sampling method, analytical results for vacuum dust samples are not likely to reflect the total dust contained within the sampling area prior to sample collection This practice generally will have a collection bias towards smaller, less dense particles." Since the bias of this method is known, microvacuum samples collected for lead analysis were used for determining background loading levels.

4.1.3 Wipe Sample Collection

Wipe samples of settled dust, from nonporous hard surfaces were collected from each unit and analyzed for asbestos, lead, dioxins, PAHs, crystalline silica, calcite, gypsum and total dust. The methods used for the collection and analysis of wipe samples are summarized in Table 4-1.

Wipe sampling employs the use of a cloth-like material (e g., gauze, Ghost Wipes™ or baby wipes), wetted or pre-moistened with a solution and is conducted by wiping an area within a template of known size.

4.1.4 Bulk Dust Sample Collection

During the development of the sampling plan and QAPP, no standard method was found for the collection of dust and particulate matter trapped in window air-conditioner filters. EPA's contractor TRC developed a procedure to collect this material by brushing the dust and particulate matter from the filter using a disposable brush. The dust was collected into a foil-lined stainless steel bowl. If sufficient material was obtained, the sample was transferred to the appropriate sample container for shipment to the laboratory The procedure is noted in Table 4-1 of this report.

In several cases there was not enough material on the window air-conditioner filter for all of the analyses to be conducted. An order prioritizing the analyses was established in the event of insufficient material collected. The first container was sent for the analysis of asbestos and man-made vitreous fibers (MMVF). If sufficient sample material was collected for the remaining parameters, the second container was sent for analysis of lead, crystalline silica, calcite and gypsum in descending priority.

Dust and particulate matter of sufficient amount could not be collected from any of the apartment air-conditioning unit filters for the analysis of PAHs and dioxins These parameters require a large quantity of material in order to conduct the analyses.

4.1.5 Quality Control Samples

Quality control (QC) samples are used to assess the sampling and analytical processes and to ensure that these processes are being conducted properly. QC samples were collected during each day of sampling. These samples included the collection of field spike wipe samples, field blanks and lot blanks. QC samples were collected for microvacuum, wipe and air samples. QC samples were not collected with the bulk dust samples due to insufficient material needed to perform the analyses. Table 4-2 provides a summary of the samples collected for this project.

As recommended in the *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*; U S. Department of Housing and Urban Development. Washington, DC, 1995; *Appendix 13.1: Wipe Sampling for Settled Lead-Contaminated Dust*, field spike wipe samples for lead analysis were prepared by the laboratory. The spike samples were sent to the sampling contractor and randomly inserted into the sample group for each building, for each day of sampling. In total, fourteen spike samples were sent indistinguishably to the laboratory with the actual wipe samples collected for lead analysis. These spike samples were labeled as ceiling wipe samples on the chain of custody in order to easily identify the sample results in the database.

Field spike samples were collected for lead analysis in order to assess if the laboratory digestion procedure used for the wipe material was capable of achieving recovery within the QC limits of 80 to 120 %. A summary of the results for the spiked samples and the calculated percent recovery is provided in Table 4-3. The results of the spike samples indicate that the laboratory was able to achieve the recovery required for the analysis of lead wipe samples within the QC limits with the exception of sample numbers 2 and 3 which were barely outside the QC limits at 79% and 78%, respectively.

Field blanks were collected for microvacuum, wipe and air samples to determine if the sample media could become contaminated during the sampling event. For air and microvacuum methods, these samples were collected by opening a separate air sampling cassette during the sample collection activities to expose it to the air and then closing the cassette. Wipe field blanks are collected by removing the wipe from its container or package, shaking the wipe open and re-folding it as would be done during the actual sampling procedure and placing the wipe back into the sample container. The field blanks are then labeled, packaged and shipped with the actual field samples for analysis Results of these samples indicate that there was no contamination above the reporting limit or health-based benchmarks that would affect the results or quality of the data.

Lot blanks were collected for microvacuum, wipe and air samples to determine if the media used to collect the samples were contaminated. The lot blanks are then labeled, packaged and shipped with the actual field samples for analysis. Results of these samples indicate that there was no contamination above the reporting limit or health-based benchmarks that would affect the results or quality of the data.

4.2 Sampling Equipment

4.2.1 Air Sampling Equipment

ANALYTE	SAMPLE MEDIA	FLOW RATE	SAMPLE PERIOD	SAMPLE PUMP
Asbestos (TEM and PCM)	0.8 um (25mm) MCEF cassette	10 L/min	480 min.	Thomas Medium Volume Diaphragm Pump
MMVF	0.8 um (25mm) MCEF cassette	10 L/min	480 min	Thomas Medium Volume Diaphragm Pump
Crystalline silica, Calcite, Gypsum, Portlandite	5 um (37mm) PVC cassette through an aluminum cyclone	2.5 L/min	480 min	Gillian GilAir3 personal sampling pump
Lead	0 8 um (37mm) MCEF cassette	10 L/min	480 min	Thomas Medium Volume Diaphragm Pump

4.2.2 Microvacuum Sampling Equipment

ANALYTE	SAMPLE MEDIA	FLOW RATE	SAMPLE PERIOD	SAMPLE PUMP
Asbestos (TEM)	0 45 um (25mm) MCEF cassette	2.0 LPM	2 minutes	Gillian GilAir3 Personal Sampling Pump
Lead	0.8 um (37mm) MCEF cassette	2.5 LPM	Minimum of 2 minutes	Gillian GilAir3 Personal Sampling Pump

4.2.3 Wipe Sampling Equipment

ANALYTE	SAMPLE MEDIA	WETTING SOLUTION	SAMPLE CONTAINER
Asbestos, MMVF	9 x 9 inch, Super Polx 1200 Class 10 Clean room wipes,	10 to 20 milliliters of a 50 / 50 mixture of 2-propanol and DI Water	4 oz. polypropylene container
Lead, Crystalline silica, Calcite, Gypsum, Total Dust	15 cm x 15 cm, Ghost Wipes™, (SKC Inc., No. 225-24fourteen)	DI Water	50 ml polyethylene centrifuge tubes
PAHs, Dioxins	3 x 3 inch, Cotton gauze	2 milliliters of acetone	125 ml Amber glass jars with PTFE-lined caps

4.2.4 Bulk Sampling Equipment

Sample equipment used for the collection of bulk dust samples from the air-conditioner unit filters included: disposable brushes, stainless steel bowl, aluminum foil and 4 oz. polypropylene containers.

4.3 Sample Numbering/Identification

The sample numbering/identification scheme was specific to the addresses, building identification numbers and apartment numbers sampled. For the purpose of maintaining confidentiality of the building owners and residents, the sample numbers are not provided in this report.

4.4 Sample Shipment

All samples were placed in plastic coolers with bagged ice or ice packs and shipped to the appropriate laboratory for analysis. All sample documentation was placed and sealed in a plastic bag and affixed to the underside of each cooler lid The lid was sealed and affixed on at least two sides with custody seals so that any sign of tampering would be visible.

TRC packaged the samples for shipment/transport to the EPA contracted laboratory as specified in the table below and on chain of custody forms.

Parameters	Shipment/Transportation Method	Laboratory
Dioxins PAHs	Shipped Overnight Courier	Paradigm Analytical 2627 Northchase Parkway SE Wilmington, NC 28405
Asbestos Lead Total Dust Crystalline silica Calcite Portlandite Gypsum MMVF (fibrous glass)	Hand Delivery: Dropped Off Daily EMSL would then ship all but the asbestos samples to their New Jersey based laboratory	EMSL 307 West 38th Street New York, NY EMSL 107 Haddon Ave. Westmont, NJ

4.5 Data Validation and Reporting

4.5.1 Validation

The validation of all organic and inorganic analytical data were performed by EPA's Quality Assurance Technical Support (QATS) contractor in accordance with the Standard Operating Procedures listed in Attachment B.

4.5.2 Verification

Any manual entry of data by the QATS contractor into the database was verified by the following procedure. This procedure was followed from the inception of the project for all spreadsheets sent by QATS to EPA for entry into the database.

a. The QATS data analyst entered the validated data into a spreadsheet format.

b. The analyst printed out a hard copy of the spreadsheet and placed it into the raw data file.

c A second QATS data review analyst then reviewed every entry that was made into the spreadsheet.

d. The review analyst then returned file to original data entry analyst if errors were found.

e. Any found errors were corrected and steps b through e were repeated.

f. Documentation of this review and verification is maintained for each data file by the QATS contractor.

Once the verification of the data were complete, the electronic file was sent to the EPA Region 2, Data Management Team and loaded into the database. All analytical results were evaluated and tabulated subsequent to validation and are presented in Tables 6-1 through 6-6. A detailed discussion of the results and development of background concentrations is provided in Section 6 0

5.0 SAMPLING PROTOCOL DEVIATIONS

The bulk samples collected were to be analyzed in the following order by the contracted laboratory: asbestos, lead, crystalline silica, calcite, gypsum and MMVF. Due to the backlog of asbestos samples at the EMSL, New York laboratory, the samples were shipped to the EMSL, New Jersey laboratory for the remaining analysis. In performing the analysis for the remaining parameters the laboratory used all of the material available therefore, the asbestos analysis was not performed on a majority of the bulk dust samples collected. This was done without notification to the EPA Project Officer

Bulk dust samples were not collected from the common areas due to the absence of window air-conditioner units.

The following are deviations from the QAPP for each day of sampling.

August 20, 2002 - Consent to sample was only obtained for one apartment and the basement laundry room in this building. In the apartment, there was a power failure for two (2) minutes during sampling. Sampling time was increased by two (2) minutes to compensate for loss of volume.

August 21, 2002 - Air samples could not be collected from the common area as there were no power outlets in the area. Counter wipes could not be collected due to lack of horizontal surfaces in the common area. Microvacuum samples could not be collected from the common area due to absence of porous surfaces.

August 22, 2002 - Microvacuum samples could not be collected from the common area due to absence of porous surfaces. In one of the apartments, the pump used for the collection of crystalline silica, calcite and gypsum (SCG) failed. The sample collection was terminated at that time and the sample data reflected abbreviated sample duration.

August 29, 2002 - There was a power failure of five (5) minutes on pump #3 being utilized for the SCG sample. The sampling time for SCG was increased by five (5) minutes to compensate for loss of volume. Microvacuum samples could not be collected from the common area due to absence of a porous surface. Air samples could not be collected from the common area as there was no power available in the area.

August 30, 2002 - Microvacuum samples could not be collected from the common area due to absence of a porous surface. The ceiling wipe sample for asbestos could not be collected from one apartment due to acoustical texturing.

September 4, 2002 - One apartment and the common area were sampled; access was denied to the second apartment unit. Microvacuum samples could not be collected from the common area due to absence of a porous surface. The common area ceiling wipe sample was collected from the duct work above dryer #3 as the ceiling had a rough stucco surface which was not suitable for wipe sampling.

September 5, 2002 - The common area was not sampled since the access agreement was not signed.

September 6, 2002 - Microvacuum samples could not be collected in one apartment and the common area from carpets/rugs or drapes as none were present Ceiling samples could not be collected in the common area due to the presence of a rough surfaced drop ceiling.

September 10, 2002 - A common area was not available for sampling.

September 12, 2002 - Couch/chair microvacuum samples could not be collected from the apartment. Samples from the common area could not be collected due to restricted access.

September 24, 2002 - Microvacuum samples could not be collected from the common area due to absence of a porous surface.

September 25, 2002 - High flow air sampling pumps in the common area shut down for twenty minutes due to power outage in part of the building. Sampling time was extended twenty minutes to compensate for loss of volume. Air sampling was terminated 110 minutes early in one unit at the request of the owner. The owner was called out for the remainder of the day.

6.0 ANALYTICAL RESULTS AND DEVELOPMENT OF BACKGROUND CONCENTRATIONS

The samples collected during this Study were analyzed to determine the concentration of each analyte in the matrix in which it was collected. The purpose of collecting and analyzing the samples was to establish background concentrations for a select group of compounds that have been identified as contaminants related to the collapse of the World Trade Center. As stated previously, these background concentrations will be used to supplement the health-based benchmarks established in the "World Trade Center Indoor Air Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks"document and may be used as an alternative cleanup value if the health-based benchmark cannot be achieved.

6.1 Methods

Deriving a background concentration for each analyte was completed using the following guidance; Guidance for Characterizing Background Chemicals in Soil at Superfund Sites (EPA 540-R-01-003, June 2001), Role of Background in the

CERCLA Cleanup Program (OSWER 9285.6-07P, April 2002), and Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (OSWER 9285.6-10, December 2002).

Evaluating environmental data that are collected to establish background concentrations of chemicals can be done using a variety of endpoints, such as reporting ranges, arithmetic or geometric means, or point-estimates based on a statistical computation. The method that is used to evaluate and interpret the data is dependent on the application of the background concentration For this study, a point-estimate that represented an upper-bound of the population mean was the desired endpoint This resulted in using a statistical approach, specifically calculating a upper confidence limit (UCL) based on the mean, for estimating an upper-bound point estimate for each analyte in its associated media.

Several different statistical methods can be used to estimate an UCL of a data set, depending on the data distribution. Two key steps were completed to estimate the UCL for these data sets.

1) Determined the distribution of the data (i.e., normal, lognormal, or neither[3]) and,

2) Computed the UCL using the appropriate confidence interval[4] (e.g., 95%, 97.5%, 99%) and statistical method for the data distribution

These two steps were performed with the ProUCL statistical software developed for EPA (Lockheed Martin 2001). Based on EPA guidance (Risk Assessment Guidance for Superfund - Part A, 1989) and standard EPA Region 2 procedures, the samples that were reported as being below the detection limit were assigned a value equal to one-half the laboratory-reported detection limit for the statistical calculations[5].

---

[3]If the distribution of the data is neither normal nor lognormal, it is recommended to use a non-parametric (i.e., distribution-free) statistic to estimate the UCL

[4]The confidence interval used to estimate the UCL was determined by the skewness of the data For mild to moderately skewed data sets (e.g., σ in the interval of 0.5 to 1) a 95% confidence interval was used, for moderate to highly skewed data sets (e.g., σ in the interval of 1 to 2) a 97.5% confidence interval was used, and for highly to extremely highly skewed data sets (e g., σ in the interval of 2 to 3) a 99% confidence interval was used.

[5]A UCL was calculated for any data set that had variability In situations where all of the samples were below the detection limit, but the detection limit varied, the UCL that was estimated was identified as a theoretical value because the mean that was calculated, from which the UCL was derived, was based only upon the detection limit and it does not include actual detected concentrations Therefore, the UCL associated with these data sets are theoretical in nature and are reported as such.

The program ProUCL tests the normality/lognormality of each data set using the Shapiro-Wilk W Test for sample sizes of 50 or smaller, and using the Lilliefors Test for sample sizes of 51 to 1000. The data sets for this project included samples sizes that are less than 50 and greater than 50, therefore both tests were used depending on the sample size for each analyte. The majority (92%) of the data sets were neither normally (0.5%) nor lognormally (7%) distributed, therefore a non-parametric statistic was used to estimate most of the UCLs.

Descriptive statistics, including the minimum, maximum, mean, median, standard deviation, coefficient of variation, skewness and variance were calculated. In addition, approximately ten different statistical methods were used to calculate UCLs for each analyte's data set. The output from these calculations also reported descriptive statistics for the log-transformed data, which included mean, standard deviation, coefficient of variation, skewness, median, 80%, 90%, 95%, and 99% quartiles. The output also included a recommendation regarding which calculated UCL was most representative of the data set. This UCL is reported in Tables 6-1 through 6-6.

The UCLs were calculated with the statistical procedures based on the findings of Singh, Singh, and Engelhardt (1997, 1999), as referenced in the ProUCL users guide (Lockheed Martin, 2001). For normally distributed data sets, the Student's t-statistic, based on an arithmetic mean, was used to calculate the UCL. For lognormally distributed data sets, one of five different computational methods was used, based on the log-transformed mean[6], depending on the skewness of the data, which was indicated by the standard deviation of the log-transformed data, and the samples size. For data sets that were neither normally nor lognormally distributed, a UCL based on the non-parametric Chebyshev theorem and arithmetic mean was used (Lockheed Martin, 2001).

As stated above, these statistical methods were completed for each analyte, sampling matrix (i e., bulk dust, air, microvacuum, and wipe samples), and space tested (i.e., resident, common area, and both combined). There were also some matrices in which multiple surfaces were sampled (e g., counters, floors, and walls), so additional calculations were conducted for different surfaces. The text that follows explains the statistical evaluation of the data and the results of the statistical analyses, as presented in tabular format (Tables 6-1 through 6-6). The values presented in these tables provide estimates of the background concentration for each compound and media.

An additional assessment was undertaken to provide a single recommended value for each analyte for the air, bulk dust, porous materials, and hard surfaces. These values, which are summarized in Table 8-1, can be used as a representative background concentration for Manhattan given the statistical limitations of the data set.

---

[6] The anti-log of the log-transformed mean is equal to the geometric mean

The recommended values were determined using two priorities:

- as first priority, a combined data set, using both the residential and common areas and all samples from a specific media (e.g., settled dust) to achieve a larger sample size, was used unless the data from the separate areas were determined not to be similar[7], in which case the second priority was used;

- the second priority used the data set for the residential areas for all samples from a specific media, as the residential data sets had the second largest sample size and this data set would reflect the background concentration within a residential apartment.

6.2 Results and Development of Background Concentrations

The following sections present a summary of the analytical results, the background values calculated, and a discussion that addresses the strengths and weaknesses for the asbestos, MMVF, lead, dioxin and PAH data sets, as well as the corresponding background value that was derived for each analyte, matrix, type of space, and type of surface. The statistical results and calculated UCLs are reported in Tables 6-1 through 6-3.

6.2.1 Asbestos[8]

Bulk Dust - There were three bulk dust samples collected and analyzed for asbestos. All three samples were collected from the residential spaces. The results for the three samples were below the detection limit of 1%. Due to the small sample size and the results all being below the detection limit, the UCL for asbestos in bulk dust could not be calculated The data suggest that background asbestos concentrations in bulk dust are less than 1%, however, the confidence in this statement is limited due to the small sample size.

Air - There were sixty-two air samples collected, forty-eight in residential spaces and fourteen in common spaces. Each of the samples were analyzed using Phase Contrast Microscopy (PCM), Transmission Electron Microscopy (TEM) AHERA, and TEM Phase Contrast Microscopy equivalents (PCMe) methods.

---

[7]The frequency of detection, range of detection, mean and calculated UCL for the residential and common area data sets were qualitatively compared to determine if they were similar. If any of the parameters were identified as not being similar, the second priority was used

[8]For this study, the term structure and fiber are used interchangeably, although there are mineralogical nuances and counting rules that make these two terms technically different In general, the analyses that were completed represent fibers, however for ease of comparison to the AHERA asbestos standard in a sister study, the term structure was adopted for all asbestos TEM analyses

PCM - There was a higher percentage of detections in the common space areas (71%) than in the residential areas (42%) although the minium and maximum detected concentrations were the same. The UCL for the common area (0.0058 f/cc) is slightly more than twice the value for the residential area (0.0023 f/cc). This difference may not be an unusual occurrence as common areas, such as laundry rooms and hallways may contain more fibrous material, especially in laundry rooms and high traffic areas. Since the common space areas and the residential areas differ, it is recommended to use the 95% UCL for the residential spaces of 0 0023 f/cc as the background value.

TEM AHERA - There was a higher percentage of detections in the common space areas (14%) than in the residential areas (4%) although the minimum and maximum detected concentrations were the same. In addition, the mean for each data set were similar. The four samples (two common area and two residential) that had detectable concentrations of asbestos were at the detection limit of 0 0004 s/cc. Since the frequency of detection was marginally different for the common space areas and the residential areas, it is recommended to use the 95% UCL for the residential spaces of 0.00024 s/cc as the background value.

TEM PCMe - There was a higher percentage of detections in the common space areas (7%) than in the residential areas (4%) although the minimum and maximum detected concentrations were the same. In addition, the mean for each data set were almost equal. The three samples (two common area and one residential) that had detectable concentrations of asbestos were at the detection limit of 0.0004 s/cc. The UCL for the common areas (0.00029 s/cc) is marginally higher than the UCL for the residential area (0.00024 s/cc). The combined data set yields a UCL that is the same value (0.00024 s/cc) as the residential UCL. Given that the residential areas and the combined data sets provide the same UCL, it is recommended to use the 95% UCL of 0.00024 s/cc as the background value.

Microvacuum - There were 162 microvacuum samples collected, with 144 from residential areas and 18 from common spaces. The microvacuum samples were collected from porous materials, such as carpets, area rugs and couches. These samples were analyzed for asbestos. The results from these analyses were quite variable between different surfaces and between the different spaces. Asbestos was detected more frequently in the common spaces (22%) and at higher concentrations (mean = 7,145 s/cm^2) than in the residential spaces (4%) with a mean concentration of 2,234 s/cm^2. In addition, the carpets in both spaces had greater mean concentrations than the other porous surfaces (i.e., couches, chairs, and drapes). As the purpose for collecting microvacuum samples for asbestos was to determine the presence or absence of asbestos in porous items, a UCL was not calculated for this data set.

Wipe - There were 146 wipe samples collected, with 104 from residential areas and 42 from common spaces The wipe samples were collected from hard surfaces including floors, walls, counters, and ceilings. These samples were analyzed for asbestos. The results from these analyses were quite variable between different surfaces and between different spaces. Overall, asbestos was detected about twice as frequently in the common areas (26%) than in the residential areas (13%). The results from the common areas had several very high concentrations reported due to detection limits being unusually high for several samples. This might artificially increase the background concentrations and for this reason the common space data sets were not used for determining the background concentration.

Based on the residential data set, the mean concentration was higher in the ceiling samples, followed by the floor samples, then the walls, and finally the counters. The UCLs for these surfaces were within an order of magnitude with the exception of the UCL for the ceiling, which was one order of magnitude higher. However, given that the primary goal is to estimate the background concentration for a residential space, it is recommended to use the entire residential data set, which includes ceilings, counters, floors, and walls to establish a background concentration for hard surfaces The 95% UCL for this data set is 6,192 s/cm^2 and would be applicable for all hard surfaces in a residential space.

6.2.2 Man-Made Vitreous Fibers

Bulk Dust - There were twenty-four bulk dust samples collected and analyzed for MMVF. All of the samples were collected from the residential spaces. The results for the twenty-four samples were below the detection limit of 1%. As all of the samples were below the detection limit and the same detection limit was used throughout the Study, the UCL for MMVF in bulk dust could not be calculated because there was no standard deviation. The data suggest that background MMVF concentration in bulk dust is less than 1%, however, the confidence in this statement is limited due to the small sample size.

Air - There were sixty-two air samples collected, with forty-eight collected from residential spaces and fourteen collected from common areas. The frequency of detection for the common spaces (29%) was higher than the residential spaces (2%), however the range of detections and means were very similar. The UCL for the combined data set is the same as the UCL for the residential data set. Given that the UCLs are the same, it is recommended to use the 95% UCL of 0 06 s/L or 0.00006 s/cc.

Wipe - There were 141 wipe samples collected, with ninety-nine collected from residential spaces and forty-two from common areas. The frequency of detection was similar between the residential (9%) and the common (11%) areas, as well as the range of detections and the mean for the wipe data set for each space. Each space had wipe samples collected from hard surfaces including ceilings, counters, floors, and walls. The samples collected from the ceiling, counters, and walls in the common spaces were all below the detection limit and a UCL could not be calculated for these surfaces. All of the surfaces sampled from the residential areas had UCLs that were within a factor of three. Given that the residential data for the different surfaces were similar, as well as the data from the common areas, it is recommended to use the entire data set, which includes the residential and common spaces. This data set provides a 95% UCL of 52 s/cm^2 as a background concentration for MMVF on hard surfaces.

6.2.3 Lead

Bulk Dust - There were nine bulk dust samples collected from residential spaces and analyzed for lead There were no bulk dust samples collected from the common areas. Lead was detected in all of the bulk samples ranging from 44 mg/kg to 242 mg/kg with a mean concentration of 126 mg/kg. The 95% UCL for this data set was calculated as 186 mg/kg. This UCL is recommended to be used as a background concentration for lead in bulk dust.

Air - There were forty-six air samples collected, with thirty-two samples collected from residential areas and fourteen collected from common areas. Only one sample, collected from a residential area, had a concentration of lead that was detectable and the lead concentration was equal to the detection limit. However, as the detection limit for the common areas and residential area samples varied slightly, a theoretical background concentration can be calculated for the common area because the range of detection limits permits a standard deviation to be calculated. The results indicate that the frequency of detection is similar between the residential areas (3%) and the common areas (0%), as well as the mean concentration. The UCL for each space is similar, 0.027 µg/m^3 for common areas and 0.032 µg/m^3 for the residential area, therefore it is recommended to use the entire data set, which includes the common area and residential area, to calculate a background concentration. The 95% UCL for the entire data set, which should be considered the calculated background concentration, is 0.03 µg/m^3

Microvacuum - There were 144 microvacuum samples collected, with 114 collected in residential areas and 18 collected in common areas. The microvacuum samples were collected from porous materials including carpets, couches, chairs, and drapes. The frequency of detection for all of the microvacuum samples collected in the residential areas (8%) was similar to the samples collected in the common areas (6%), as were the ranges, mean, and calculated UCLs for the data sets for each space and each surface. Given the similarity between the data sets, both between spaces and between surfaces, it is recommended to use the entire microvacuum data set for estimating the background concentration of lead in porous surfaces. This yields a 95% UCL of 1.98 µg/ft^2 for the background concentration of lead in porous surfaces.

Wipe - There were 114 wipe samples collected, with 80 collected in residential areas and 34 collected in common areas. The wipe samples were collected from hard surfaces including counters, floors and walls. The frequency of detection between the residential areas (49%) and the common areas (53%) for all of the wipe samples from each areas are similar, as are the range of detections and means, with the exception of the maximum detected concentration on the floor in the common area, which was about five times higher than the residential area. Although the data sets are very similar for both the spaces and surfaces, the inclusion of the maximum value for the floor in the common area of 49.2 µg/ft^2 in the entire data for areas skews the data set and results in a 95% UCL of 4 59 $\mu g/ft^2$. Alternatively, if only the residential data set is used, the calculated 95% UCL provides a value of 1.78 $\mu g/ft^2$. Either value would be an acceptable background concentration for hard surfaces, however it is recommended to use the 95% UCL value of 1 78 $\mu g/ft^2$ that was calculated using only the residential data set because of the marginal difference in the maximum detected concentration in the common areas and residential areas.

6.2.4 Dioxin

Wipe - There were 114 wipe samples collected, with 80 samples collected from residential areas and 34 samples collected from common areas. The samples were collected from hard surfaces including counters, floors, and walls. The samples were analyzed for dioxin and furan congeners and the results were reported in 2,3,7,8-tetracholorodibenzo-p-dioxin (TCDD) equivalents (i.e., TEQs) Any sample which was below the detection limit for any specific congener group was assigned a value of ½ of the detection limit before calculating the TEQ, thus for the statistical analysis the reported TEQ was used without any further modifications. In addition, the TEQ value that was used for estimating the background concentration was the estimated maximum potential concentration (EMPC). The TEQ EMPC value uses data that indicated the detected presence of a compound above zero but did not meet all of QA/QC reporting level criteria.

The frequency of detection between the residential areas (23%) and the common areas (20%) were similar, as were the range of detections, means, and UCLs. The similarity between the data sets for the residential areas and the common areas permits the use of the entire data set for estimating the background concentration. The 95% UCL calculated from the entire dioxin data set is 0.693 ng/m^2, which can be used as an estimate of the background dioxin concentration on hard surfaces.

6.2.5 Polycyclic Aromatic Hydrocarbons

Wipe - There were 113 wipe samples collected, with 80 samples collected from residential areas and 33 samples collected from common areas. The samples were collected from hard surfaces including counters, floors, and walls. The samples were analyzed for 23 PAH compounds, of which seven of the compounds are used to calculate a toxicity equivalence factor (TEF). The analytical results indicate that none of the 23 PAH compounds were detected and the TEF for each sample would be equivalent to 290 $\mu g/m^2$ The detection limit was the same for each sample that was analyzed, therefore a UCL cannot be calculated for the residential or common area data sets due to not having a standard deviation. The data suggest that the background concentration of PAHs on hard surfaces is less than the detection limit of 0.25 μg (i.e., 250 $\mu g/m^2$) for individual PAHs or 290 $\mu g/m^2$ for the calculated TEF.

6.3 Minerals and Total Dust Results - Development of Background Concentrations

The following sections present a summary of the analytical results, the calculated background values and a discussion that addresses the strengths and weaknesses for the crystalline silica, calcite, gypsum, portlandite and total dust data sets, as well as the corresponding background value that was derived for each analyte, matrix, type of space and type of surface The statistical results and calculated UCLs are reported in Tables 6-4 through 6-6.

6.3.1 Crystalline Silica

6.3.1.1 Alpha-quartz

Bulk Dust - There were nine bulk dust samples collected from residential areas. These samples were analyzed for alpha-quartz. There were no bulk samples collected from common areas. Eight of the samples detected alpha-quartz above the detection limit with a mean value of 2 2%. The 95% UCL for alpha-quartz in bulk dust is 3.66% and this value can be used as an estimate of the background concentration.

Air - There were forty-six air samples collected, with thirty-two collected from residential areas and fourteen collected from common areas. The frequency of detection for the residential areas (25%) and the common areas (29%) are similar, although the range of detection and mean concentrations are different. This is primarily due to one sample value from the residential areas being elevated above the rest of the samples in the data set. This value was determined to be a valid result and therefore was kept in the data set. There was some variability between the residential and common area, primarily due to one sample, however following the priorities identified earlier it is recommended to use residential data set for estimating the background concentration due the difference in the maximum detected concentrations. The 95% UCL for the residential data set is 61.9 $\mu g/m^3$ which can be used as an estimate of background concentration for alpha-quartz in air.

Although the value estimated above has been identified as the recommended background concentration, an additional calculation was conducted without the elevated value to determine a UCL that is not influenced by the elevated value. The 95% UCL for the residential data that has the elevated value removed is 7.8 $\mu g/m^3$. This value may be more representative of background, however it is unclear how common the elevated value may be in an urban environment, therefore the recommended UCL is 61.9 $\mu g/m^3$ with the recognition that it may be much lower (i.e., 7.8 $\mu g/m^3$).

Wipe - There were 114 wipe samples collected with eighty-one collected from residential areas and 33 collected from common areas. The wipe samples were collected from hard surfaces including counters, floors, and walls. The frequency of detection between the residential areas (38%) and the common areas (61%) for combined surfaces are not similar and the mean concentration for each type of surface sampled are not similar between the residential and common areas. Since the primary focus of this Study was to determine background concentrations for residential areas, it is recommended to use the data set for the residential spaces to estimate the background concentration. The mean concentrations from each of the surface types in the residential data set are similar, varying by less than a factor of two, therefore it is recommended to use the entire residential data set, which includes the results from the counters, floors, and walls. The 95% UCL for this data set is 79.6 μg/ft^2. This value can be used as an estimate of the background concentration for alpha-quartz on hard surfaces.

6.3.1.2 Cristobalite

Bulk Dust - There were nine bulk dust samples collected from residential areas. These samples were analyzed for cristobalite. There were no bulk samples collected from common areas. None of the samples detected cristobalite above the detection limit. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated. The 97.5% UCL for cristobalite in bulk dust is 4.69% and this value can be used as an estimate of the background concentration.

Air - There were forty-six air samples collected with thirty-two collected from residential areas and fourteen collected from common areas. The samples were analyzed for cristobalite. Cristobalite was not detected in any sample. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated using the entire combined data set from the residential and common areas. The 95% UCL for the combined data set is 9.3 μg/m^3, which can be used as an estimate of the background concentration of cristobalite in air.

Wipe - There were 114 wipe samples collected with eighty samples collected in residential areas and thirty-four in common areas. The samples were collected from hard surfaces including counters, floors, and walls. The samples were analyzed for cristobalite. The frequency of detection for the residential areas (0%) and the common areas (3%) were similar, as were the range of detection and mean concentrations. Based on the similarity of the data sets between spaces and between surfaces, it is recommended to use the entire data set, combined for surfaces, to estimate the background concentration. The 95% UCL from this data set provides a value of 103 7 μg/ft^2 as an estimate of the background concentration of cristobalite on hard surfaces.

6.3.1.3 Tridymite

Bulk Dust - There were nine bulk dust samples collected from residential areas. These samples were analyzed for tridymite. There were no bulk samples collected from common areas None of the samples detected tridymite above the detection limit. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated. The 97.5% UCL for tridymite in bulk dust is 4 69%, and this value can be used as an estimate of the background concentration.

Air - There were forty-six air samples collected with thirty-two collected from residential areas and fourteen collected from common areas. The samples were analyzed for tridymite. Tridymite was not detected in any sample. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated using the entire combined data set from the residential and common areas The 95% UCL for the combined data set is 9.3 $\mu g/m^3$, which can be used as an estimate of the background concentration of tridymite in air.

Wipe - There were 114 wipe samples collected with eighty collected from residential areas and thirty-four collected from common areas The samples were collected from hard surfaces including counters, floors, and walls. The samples were analyzed for tridymite. Tridymite was not detected in any sample, however since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated using the entire combined data set for all surfaces from the residential and common areas. The 95% UCL for the combined data set is 99.8 $\mu g/ft^2$, which can be used as an estimate of the background concentration of tridymite on hard surfaces

6.3.2 Calcite

Bulk Dust - There were nine bulk dust samples collected from residential areas. These samples were analyzed for calcite. There were no bulk samples collected from common areas. Only one of the samples detected calcite above the detection limit The 95% UCL for calcite in bulk dust is 3.41% and this value can be used as an estimate of the background concentration.

Air - There were forty-six air samples collected with thirty-two collected from residential areas and fourteen collected from common areas. The samples were analyzed for calcite Calcite was not detected in any sample However, since the detection limit for the samples varied slightly, a theoretical background concentration was calculated using the entire combined data set from the residential and common areas. The 95% UCL for the combined data set is 9.3 $\mu g/m^3$, which can be used as an estimate of the background concentration of calcite in air

Wipe - There were 114 wipe samples collected with eighty samples collected in residential areas and thirty-four in common areas. The samples were collected from hard surfaces including counters, floors, and walls. The samples were analyzed for calcite. The frequency of detection for the residential areas (3%) and the common areas (3%) were the same, and the range of detection and mean concentrations were similar. Based on the similarity of the data sets between spaces and between surfaces, it is recommended to use the entire data set, combined for surfaces, to estimate the background concentration. The 95% UCL from this data set provides a value of 132 3 $\mu g/ft^2$ as an estimate of the background concentration of calcite on hard surfaces.

6.3.3 Gypsum

Bulk Dust - There were nine bulk dust samples collected from residential areas. These samples were analyzed for gypsum. There were no bulk samples collected from common areas. Only one of the samples detected gypsum above the detection limit. The 95% UCL for gypsum in bulk dust is 2.33%, and this value can be used as an estimate of the background concentration.

Air - There were forty-six air samples collected with thirty-two collected from residential areas and fourteen collected from common areas The samples were analyzed for gypsum. Gypsum was not detected in any sample. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated using the entire combined data set from the residential and common areas. The 95% UCL for the combined data set is 9.3 $\mu g/m^3$, which can be used as an estimate of the background concentration of gypsum in air.

Wipe - There were 114 wipe samples collected with eighty collected from residential areas and thirty-four collected from common areas. The samples were collected from hard surfaces including counters, floors, and walls. The samples were analyzed for gypsum. Gypsum was not detected in any sample. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated using the entire combined data set for all surfaces from the residential and common areas. The 95% UCL for the combined data set is 49.9 $\mu g/ft^2$, which can be used as an estimate of the background concentration of gypsum on hard surfaces.

6.3.4 Portlandite

Bulk Dust - There were nine bulk dust samples collected from residential areas. These samples were analyzed for portlandite. There were no bulk samples collected from common areas. None of the samples detected portlandite above the detection limit. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated The 95% UCL for portlandite in bulk dust is 4.69% and this value can be used as an estimate of the background concentration.

Air - There were forty-six air samples collected with thirty-two collected from residential areas and fourteen collected from common areas. The samples were analyzed for portlandite. Portlandite was not detected in any sample. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated using the entire combined data set from the residential and common areas. The 95% UCL for the combined data set is 9.3 $\mu g/m^3$, which can be used as an estimate of the background concentration of portlandite in air.

Wipe - There were 114 wipe samples collected with eighty collected from residential areas and thirty-four collected from common areas. The samples were collected from hard surfaces including counters, floors, and walls. The samples were analyzed for portlandite. Portlandite was not detected in any sample. However, since the detection limit for the samples varied slightly, a theoretical background concentration can be calculated using the entire combined data set for all surfaces from the residential and common areas. The 95% UCL for the combined data set is 99.8 $\mu g/ft^2$, which can be used as an estimate of the background concentration of portlandite on hard surfaces.

6.3.5 Total Dust

Wipe - There were nine wipe samples collected from residential areas and analyzed for total dust. Dust was detected in all nine samples with a mean concentration of 10.9 mg/ft^2. The 95% UCL for this data set was 14.4 mg/ft^2, which can be used as an estimate of the background concentration of total dust

7.0 HISTORICAL STUDIES ON BACKGROUND CHARACTERIZATION

7.1 Background Literature Search Results

The WTC Background Study was conducted to address the following question: What were the baseline levels for a select group of contaminants in residential dwellings in lower Manhattan had the Trade Center never collapsed? A complete set of data were not available that captured the baseline levels of WTC COPCs in the settled dust and indoor air of residential dwellings in lower Manhattan prior to 9/11/01. However, there are various sources of data that partially address the specific aim of the WTC Background Study. This section evaluates the findings of historical studies on background by way of a comparison to the methods and results of the WTC Background Study.

A search of the literature was conducted for published data on residential indoor measurements of WTC COPCs The focus was for relevant data, collected in the past ten to fifteen years, that may be used for comparison with the measurements from the WTC Background Study. Worth noting are the multiple factors that limit the representativeness of historical studies to the WTC Background Study. They include: variations in sampling and analytical methods; characteristics of the housing stock (e.g., age, type and upkeep) and seasonal variability.

7.1.1 Residential Indoor Airborne Asbestos Measurements

The literature citations on airborne asbestos measurements focused mainly on occupational environments. Some information is available for schools and other public buildings. Very few studies described measurements made in residential settings.

There are a number of analytical techniques (PCM, TEM, direct preparation, and indirect preparation), as well as different units of measurements reported in the literature for airborne asbestos concentration. HEI (1991) listed eleven different measurement units that could be encountered in the literature for asbestos fibers analyzed by TEM. Another factor to note is how the average or mean value is determined from a set of measurements Some studies treat all samples with no asbestos structures/fibers counted as 0 s/cc or 0 f/cc and not as a "less than" detection limit (Van Orden et al. 1995).

Presented in Table 7-1 is a summary of U.S. residential building average asbestos concentrations by direct TEM as found in the literature search

7.1.2 Settled Asbestos Dust Measurements

Ewing (2000) reported a geometric mean of 1000 s/cm^2 for samples collected in six buildings without friable asbestos-containing surfacing materials. The 28 microvacuum samples were collected and analyzed as described in the ASTM Method D 5755-95 or the earlier draft-EPA method (Clark 1989). The sampled surfaces would be considered non-porous and usually had visible dust on them. The surface types included polished stone, metal, polished wood, and plastic. Neither the types of buildings nor their locale were identified. The Study reported a geometric, rather than arithmetic, mean as a measure of central tendency. Table 7-2 is extracted from that report.

7.1.3 Airborne Man-Made Vitreous Fibers Measurements

Man-made vitreous fibers (MMVFs) are also known as synthetic vitreous fibers (SVFs) ATSDR (2001) reported that airborne concentrations of MMVFs in outdoor and indoor air samples usually are ≤0 0001 f/cc. Measurements at workplaces that manufacture MMVF have been reported to be ≤0.1 to 1 f/cc. Airborne concentrations > 1 f/cc have been observed during the installation of insulation in a home or building, but these high levels would drop to pre-installation values within 1 or 2 days.

As summarized by ATSDR (2002), a report by Carter et al (1999) used both PCM and SEM to study air samples from 51 residential and commercial buildings throughout the United States Only 2 of the 50 samples analyzed by SEM were found to contain respirable MMVFs The MMVF concentrations were not included in the ATSDR (2002) summary.

7.1.4 Man-Made Vitreous Fibers in Settled Dust or Soil

According to the ATSDR (2002), no data exist pertaining to the ambient levels of MMVFs in soil or sediment. The literature search also has not located data on MMVF loading in residences.

7.1.5 Lead Levels in the Ambient Air

As reviewed by ATSDR (1999), lead levels in the ambient air vary widely but usually decrease with increasing distance (both vertical and horizontal) from emission sources. The EPA (1996) has established the National Ambient Air Quality Standard for lead of 1.5 μg/m^3, quarterly average concentration. Composite urban air measurements of lead for 1991 were reported at 0.08 μg/m^3 (EPA 1996) In 1988, the average lead concentration for 139 urban air-monitoring sites around the United States was 0.085 μg/m^3 and remained relatively unchanged, at 0.04 μg/m^3, when estimated between 1994 and 1995 (ATSDR, 1999). Indoor air lead levels are generally 0.3 to 0.8 times lower than the corresponding outdoor levels, with an average ratio of 0.5 (ATSDR 1999).

7.1.6 Residential Settled Lead Dust Measurements

Lanphear et al. (1995) reported lead loading measurements from a study of residences of 205 children in Rochester, NY House dust samples were collected using two vacuum methods and a wipe method The geometric mean values from the microvacuum measurements were 1 $\mu g/ft^2$ and 3 $\mu g/ft^2$ for noncarpeted floors and carpeted floors, respectively. The geometric mean value from their wipe sample measurements were 16 $\mu g/ft^2$ and 11 $\mu g/ft^2$ for noncarpeted floors and carpeted floors, respectively.

Lanphear et al. (1998) reported a geometric mean for floor dust lead loading of 13.5 $\mu g/ft^2$ from their pooled analysis of 12 epidemiologic studies

Gallicchio et al. (2002) compared household lead exposure assessment methods in an old urban community (although the specific locale was not identified). The median values for dust lead loading were 12 $\mu g/ft^2$ and 5 $\mu g/ft^2$ for noncarpeted floors and carpeted floors, respectively. The measurements showed a large variation in lead load levels. Table 7-3 is extracted from the report's statistics summary.

The U.S. Department of Housing and Urban Development (HUD 2001) reported the arithmetic mean for floor dust lead loading stratified by geographic location and age of housing. Table 7-4 is extracted from the HUD summary statistics.

7.1.7 Dioxins in Soil and Settled Dust

ATSDR (1998) concluded that concentrations of chlorinated dibenzo-*p*-dioxins (CDDs) in soil are typically higher in urban areas than in rural areas. The highest CDDs in soil concentrations are associated with industrial sites, with CDD levels ranging from the hundreds to thousands parts per trillion. In general, the concentration of CDDs in soil near the site of a municipal waste incinerator would increase in concentration with increasing degree of chlorination. Heptachlorinated dibenzo-*p*-dioxin (HpCDD) and octa-chlorinated dibenzo-*p*-dioxin (OCDD) congeners are typically found at higher concentrations than the tetrachlorinated dibenzo-*p*-dioxin (TCDD), pentachlorinated dibenzo-*p*-dioxin (PeCDD), and hexachlorinated dibenzo-*p*-dioxin (HxCDD) congeners in soil and sediments.

Christmann et al. (1989) collected indoor household dust samples and analyzed the dust samples for CDDs. The dust samples were collected with a vacuum cleaner from rooms with furniture treated with a wood preservative. The wood preservative contained CDD-contaminated pentachlorophenol (PCP). Average mass concentrations of CDDs found in the dust samples were: 191 $\mu g/kg$ of OCDD, 20 $\mu g/kg$ of HpCDD, 2.5 $\mu g/kg$ of HxCDD, 0.9 $\mu g/kg$ of PeCDD, and 0.2 $\mu g/kg$ of TCDD.

7.1.8 Polycyclic Aromatic Hydrocarbons in Sediment and Soil

No citation was found during the literature search for surface loading of PAHs in the indoor residential environment. ATSDR (1995) reported the results of several studies, published from 1973 through 1987, for background concentrations (µg/kg) of 15 PAHs in rural, agricultural, and urban soils from the United States and other countries. The ATSDR summary is reproduced here as Table 7-5.

7.2 Comparison of WTC Background Study to Other Studies

Section 7.1 summarized the relevant studies that addressed background concentrations of COPCs in the residential indoor environment. This section is focused on the comparison of those studies to the WTC Background Study. As previously mentioned in Section 7.1, there are numerous factors that limit the ability to make direct comparisons between studies cited in the open literature that characterize background levels of the COPCs and the site-specific WTC Background Study. Thus, a qualitative discussion of study comparability needs to viewed accordingly Still, where studies were identified that addressed background concentrations in a manner relevant to the WTC Background Study a comparison was performed. Where historical studies are described as being generally concordant with the findings in the WTC Background study, some disparities in study design, sampling/analytical protocols and results may still exist.

7.2.1 Comparison of Airborne Asbestos Concentrations

The WTC Background Study obtained airborne asbestos measurements from residential dwellings and common spaces. Analysis was performed by TEM using two different counting methods - total asbestos fibers greater than 0.5 µm (as per AHERA counting rules), and asbestos fibers greater than 5 µm (PCMe) - and, by phase contrast microscopy (PCM). The literature review focused on PCMe measurements as this metric employs an analytical technique (TEM) that distinguishes asbestos from other fibrous material and counts only long fibers (i.e., > 5 µm) - those most closely associated with adverse health effects (i.e., cancer).

The Consumer Product Safety Commission (CPSC 1987) Study from the literature review was identified as providing relevant comparisons to the WTC Background Study. This study reported on airborne asbestos concentration in houses that contained asbestos containing material (ACM). In 15 houses in Cleveland and 15 houses in Philadelphia the mean asbestos concentration was 0.00023 f/cc and 0.00007 f/cc, respectively A total of 30 samples were taken in Cleveland and 29 in Philadelphia (see Table 7-1) In the WTC Background Study, a total of 62 samples from residences and common spaces (see Table 6-1) were obtained. The mean asbestos (PCMe) concentration was 0.00022 s/cc. This value is consistent with the mean value reported from Cleveland and marginally higher than the mean value reported in Philadelphia.

The primary strength of the above comparison is the common metric (PCMe) employed to measure airborne asbestos concentration It also focuses on urban settings similar to New York. However, there are a number of limitations. The CPSC Study reported on houses with ACM. The known existence of ACM in the CPSC Study homes would likely serve as a positive bias. Also the particular housing stock differed, the CPSC Study looked at individual houses whereas the WTC Background Study focused on apartments. The HEI (1991) summation of the CPSC Study did not report the frequency of non-detects or what concentration was assigned to non-detects

7.2.2 Comparison of Asbestos Settled Dust Concentrations

The WTC Background Study collected measurements of asbestos load (fibers per unit area) in settled dust by two methods. Microvacuum (ASTM D 5755-95) and wipe sampling (ASTM D 6480-99). Microvacuum sampling was performed on porous surfaces (carpets and couches) and resulted in the collection of 162 samples, while 146 wipe samples were collected on hard surfaces (ceilings, counters, walls and floors). The arithmetic mean for asbestos loading was 2,783 s/cm^2 for the microvacuum samples and 37,174 s/cm^2 for the wipe samples. The literature search identified a study by Ewing (2000) that reported a geometric mean of 1,000 s/cm^2 for samples collected in six buildings without friable asbestos-containing surfacing materials.

Little in the way of meaningful comparison can be made between the Ewing and WTC Background Studies. Three significant shortcomings exist. First, unlike the WTC Background Study, the Ewing Study reports a geometric, rather than arithmetic, mean. Based on the number of samples (n=28) and maximum value (210,000 s/cm^2), it is evident that the arithmetic mean (calculated by EPA for the purpose of comparison) was greater (> 7,000 s/cm^2) than the geometric mean (1,000 s/cm^2) reported in the Ewing Study. Second, the microvacuum samples in the Ewing Study were obtained from hard surfaces, whereas the WTC Background Study used microvacuum sampling only on porous surfaces. Finally, the building type was not identified in the Ewing Study.

7.2.3 Comparison of Airborne Man-Made Vitreous Fiber (MMVF) Concentrations

The WTC Background Study reported a mean concentration of 0.000042 s/cc (95% UCL = 0.00006 s/cc) in a sample size of 62. ATSDR (2002) reported that airborne concentrations of MMVFs in outdoor and indoor air samples usually are ≤ 0.0001 f/cc. Accordingly, the airborne concentration of MMVFs in the WTC Background Study appears consistent with background measurements reported in the literature although the cited reference is very general and does not provide sufficient information to make a detailed comparison.

7.2.4 Comparison of Man-Made Vitreous Fibers in Settled Dust or Soil

The WTC background Study reported results of MMVF in bulk dust and wipe samples. Of the 24 samples collected from bulk dust, all were below the detection limit of 1%. The following results were reported for 141 wipe samples collected: frequency of detection (14/141); range (29 - 286 s/cm^2) and mean of 38 s/cm^2 (95% UCL = 52 s/cm^2). ATSDR (2002) reports that no data exist pertaining to the ambient levels of MMVFs in soil or sediment The literature search also has not located data on MMVF loading in residences.

7.2.5 Comparison of Lead Concentrations in the Ambient Air

The WTC Background Study reported a mean concentration of 0.027 µg/m^3. For the 46 samples collected. No studies on background lead concentration in residential dwellings were identified in the literature search. ATSDR (1999) reported that lead levels in the ambient air vary widely but usually decrease with increasing distance (both vertical and horizontal) from emission sources. The composite urban air measurement of lead for 1991 was 0.08 µg/m^3 (EPA 1996) ATSDR (1999) estimated urban airborne levels for the years 1994-1995 to be 0.04 µg/m^3. Indoor air lead levels are generally 0 3-0.8 times lower than the corresponding outdoor levels, with an average ratio of 0.5 (ATSDR 1999)

From the historical information reported above, a rough estimate of indoor airborne lead concentration in urban areas can be made by multiplying the composite ambient air concentration (0 04 µg/m^3) by 0.5 (average value of indoor/outdoor concentrations) to give a product of 0.02 µg/m^3. This value is consistent with the mean concentration 0 027 µg/m^3 found in the WTC Background Study.

7.2.6 Comparison of Settled Lead Dust Measurements

The WTC Background Study recorded lead measurements in settled dust by concentration (mass per unit mass) and load (mass per unit area). In addition, the load measurements were obtained by wipes for hard surfaces and microvacuum for porous surfaces. The following mean measurements were reported for residential dwellings and common spaces:

Sample Type	Number of Samples	Mean
bulk dust	9	119 mg/kg
microvacuum	162	1.51 µg/ft^2
wipe (all samples)	114	1.75 µg/ft^2
wipe (all uncarpeted floors)	34	3.91 µg/ft^2
wipe (uncarpeted residential floors)	25	1 82 µg/ft^2

Unlike the other contaminants included in the WTC Background Study, settled dust lead levels in residential dwellings have been extensively studied. The study by Lanphear et al (1998) focused on the relationship between lead-contaminated house dust and children's blood lead levels. This Study evaluated pooled epidemiologic data from many different communities, some of them with significant sources of lead contamination from activities such as mining sand smelting. Consequently, reported lead levels are likely to be biased high. Another factor that compromises the comparison of results to the WTC Background Study is that the average lead load (13.5 $\mu g/ft^2$) on floors is reported as a median rather than mean value. Lastly, the measurements were performed by multiple sampling procedures, including wipe sampling and both high/low flow vacuum techniques.

The study by Gallicchio et al. (2002) focused on a comparison of methods (wipe, questionnaire, and visual inspection) to assess household lead levels. An advantage is that its targeted community (i.e , "old and urban") is much like New York City However, the Study selected low socio-economic status (SES) households (i.e., Medicaid recipients) - which due to less available resources for building maintenance may result in a positive bias. Also, like the Lanphear Study, lead loadings (12 $\mu g/ft^2$ and 5 $\mu g/ft^2$ for non-carpeted floors and carpeted floors, respectively) were reported as median rather than mean values.

The most appropriate comparison to the WTC background Study can be made with the Housing and Urban Development (HUD 2001) survey on lead in housing. Table 7-4 provides the distribution of lead loading by wipe sampling methodology in U.S. housing for uncarpeted floors. This data is broken down by census region and building age. In the Northeast, there is a greater than five-fold increase in lead load in pre-1939 versus post-1939 housing. Excluding the pre-1939 housing (mean 24.0 $\mu g/ft^2$), the weighted mean lead load for 1940 - 1998 housing stock is 3.45 $\mu g/ft^2$. The results from the HUD evaluation are consistent with the results of lead load obtained in the WTC Background Study residential units for uncarpeted floors (i.e., mean = 1.82 $\mu g/ft^2$ and 95% UCL = 2.96 $\mu g/ft^2$). This comparison benefits from both studies reporting results in the same metric (i.e., arithmetic means) for the same surfaces (uncarpeted floors) by the same methodology (wipe sampling). A limited disadvantage of the comparison is the gross characterization of housing by geographic location (e.g., Northeast) in the HUD survey and the exclusion of pre-1939 housing stock.

7.2.7 Comparison of Dioxin Concentration in Settled Dust

The WTC Background Study reported in a mean dioxin concentration of 0.644 ng/m^2 (95% UCL = 0.693 ng/m^2) for 80 wipe samples. Results were reported for dioxin toxicity equivalents (TEQs). The literature search identified no studies that reported surface loading (mass per unit area) of dioxin in settled dust in residential dwellings. The study by Christmann et al. (1989) reported concentrations (mass per mass or $\mu g/kg$) of various dioxin congeners (see Section 7.1.7). Converting these results into dioxin TEQs yields a value of 1 34 $\mu g/kg$ (or ng/g). Multiplying by an average dust load of 500 mg/m^2 or 0.5 g/m^2 results in an estimated dioxin TEQ load of 0.67 ng/m^2 (1 34 ng/g x 0.5 g/m^2).

The dioxin TEQ load of 0.67 ng/m^2 that was estimated from the Christmann Study is consistent with the mean concentration obtained from the WTC Background Study. However, the comparison has a number of limitations. The Christmann Study reported dioxin results in units of concentration (mass per mass), thus necessitating a conversion to the metric (mass per area) used in the WTC background Study. This required employing an estimate of average dust load in a residential dwelling, a value that can vary considerably depending on housekeeping habits. Also, the Christmann Study collected samples from households that contained furniture treated with a wood preservative. This may serve to bias the results high. Finally, the Christmann Study employed a vacuum sampling method whereas the WTC Background Study collected wipe samples

7.2.8 Comparison of Polycyclic Aromatic Hydrocarbon Concentration in Settled Dust

All 80 wipe samples collected in the WTC Background Study were reported to be below the limits of detection (290 $\mu g/m^2$, benzo[a]pyrene equivalents). No citations were found in the literature search for surface loading of PAHs in the indoor residential environment. Consequently, no comparison is possible with the PAH surface loading results reported in the WTC Background Study.

8.0 DISCUSSION

The objective of this Study was to determine indoor baseline levels or background concentrations for a specific group of compounds that are associated with the World Trade Center collapse These background concentrations will be used to supplement the health-based benchmarks established in the "World Trade Center Indoor Air Assessment Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks"document and may be used as an alternative cleanup value if the health-based benchmark cannot be achieved.

The compounds of interest were asbestos, man-made vitreous fibers, lead, dioxin, polycyclic aromatic hydrocarbons, and crystalline silica. In addition to these compounds, data were also collected for calcite, gypsum, portlandite, and total dust. A combination of air samples, microvacuum samples, wipe samples, and bulk dust samples were collected to evaluate these compounds in residential buildings and in common areas of residential buildings. The microvacuum samples were collected from a variety of porous surfaces, while the wipe samples were collected from a variety of hard surfaces. The data were evaluated separately for each type of sample, type of space, and each compound

In addition, the data were evaluated for groups of similar data, such as all residential lead wipe data. The combined of analyses provided a combination of 192 background concentrations, which represents 95% upper confidence limits on the arithmetic means Similar subsets of these 192 data points (e.g., by compound or by media.) were then qualitatively compared to determine a representative background concentration for each compound in air, bulk dust, porous materials, and hard materials. The recommended values are presented below in Table 8-1. The values presented in the table are an upper-bound statistical estimation of the true mean of the sample population. The upper-bound confidence limit is 95%, which represents the confidence that the true mean is equal or lower to the value that is presented in the table

Table 8-1. Background concentrations that were derived based on the analytical results from the samples collected in this study. The concentrations listed in the table represent the 95% upper confidence limit (UCL) on the arithmetic mean.

Compound	Air	Settled Dust		
		Bulk Dust	Porous Surface	Hard Surface
Asbestos		n/a (<1%)		6,192 s/cm^{2R}
Asbestos - PCM	0.0023 s/cc^{R}			
Asbestos - TEM AHERA	0.00024 s/cc^{R}			
Asbestos - TEM PCMe	0.00024 s/cc$^{R/T}$			
MMVF	0.00006 s/cc$^{R/T}$	n/a (<1%)		52 s/cm^{2T}
Lead	0.03 µg/m^{3T}	186 mg/kg^{R}	1.98 µg/ft^{2T}	1.78 µg/ft^{2R}
Dioxin				0.693 ng/m^{2T}
PAH				n/a (<290 µg/m^{2})
Alpha-quartz (w/o max. value)	61.9 µg/m^{3R} (7.8 µg/m^{3R})	3.66 %^{R}		79.6 µg/ft^{2R}
Calcite	*9.3 µg/m*^{3T}	3.41 %^{R}		132.3 µg/ft^{2T}
Cristobalite	*9.3 µg/m*^{3T}	*4.69 %*^{R}		103.7 µg/ft^{2T}
Gypsum	*9.3 µg/m*^{3T}	2.33 %^{R}		*49.9 µg/ft*^{2T}
Portlandite	*9.3 µg/m*^{3T}	*4.69 %*^{R}		*99.8 µg/ft*^{2T}
Tridymite	*9.3 µg/m*^{3T}	*4.69 %*^{R}		*99.8 µg/ft*^{2T}
Total Dust				14.4 mg/ft^{2R}

n/a - indicates that a upper confidence limit could not be calculated, value in parenthesis indicates that the value is less than the detection limit
italics - indicates a theoretical UCL due to all data being below the detection limit
T - indicates the total data set was used
R - indicates only the residential data set was used

The estimated background concentrations that were calculated were compared to literature values when available. Values reported in the literature regarding asbestos and MMVF in air, and lead and dioxin in settled dust from urban environments, that were collected and analyzed using methods similar to this Study, are consistent to the values generated by the samples collected in this background Study (Table 8-2). The consistent nature indicates that the concentrations observed from this Study population are similar to other urban environments.

The literature search conducted as part of this evaluation highlighted data gaps in the scientific literature for several of the compounds for which data were collected These compounds include MMVF, crystalline silica, calcite, gypsum, and portlandite. The data collected and the calculated background concentrations provide a source of data that can be used to address these data gaps.

In general, the data sets for samples that were collected in residential areas and common areas were similar, however there were data sets in which the detected concentrations in common area were nominally higher than the residential spaces The activity pattern, amount of foot traffic, type of cleaning, and frequency of cleaning may differ between these spaces, and some combination of these factors may be responsible for this observation.

Table 8-2. Comparison of estimated background values from this study to background or historical values reported in the scientific literature for select compounds.

Compound	Estimated Background UCL Value	Historical/Literature Value
Asbestos - PCMe	0.00024 s/cc	0.00022 s/cc[(1)]
MMVF - air	0.00006 s/cc	≤0.0001 f/cc[(2)]
Lead - air	0.03 $\mu g/m^3$	0.02 $\mu g/m^3$[(3)]
Lead - wipe floors	3.91 $\mu g/ft^2$	3.45 $\mu g/ft^2$[(4)]
Dioxin - wipe	0.693 ng/m^2	0.67 ng/m^2[(5)]

(1) Consumer Product Safety Commission Study 1987

(2) ATSDR 2002.

(3) Calculated value from EPA historic ambient air lead data

(4) HUD 2001

(5) Christmann 1989

As with any statistical evaluation, decisions made regarding the data must be taken into consideration when discussing and applying the results. For this evaluation, there were several decisions that were made regarding the data sets that affect the confidence in the estimated background concentrations.

The first is that when a sample was reported to be below the detection limit, it was assigned a value of ½ the detection limit. A sample that is listed as being below the detection limit may correspond to a concentration that is actually or virtually zero, or it may correspond to a concentration that is very close to the detection limit. By utilizing ½ of the detection limit for samples that are below the detection limit, the true background concentration may be over- or under-estimated. However, this approach consistently assigns a mid-point value that should result in an estimation that is closer to the actual mean than if either zero or the detection limit had been assigned for each sample that was below the detection limit. This is an important concept given that many of the data sets evaluated contained a large percentage of samples that were below the detection limit. As illustrated in Table 8-3, the UCLs presented in Table 8-1 would decrease or increase, respectively, by approximately the same margin if either zero or the detection limit would have been substituted for the samples that were below the detection limit. Data sets with a frequency of detection of less than eight percent would vary by more than 50%, although using ½ of the detection limit provides an estimated value that is within the middle of the range and should be a better estimation of the true mean.

Another decision that was made was to calculate UCLs for all of the data sets regardless of the sample size or frequency of detection. EPA generally estimates UCLs for data sets that have a sample size of greater than or equal to ten. For this assessment several UCL calculations were performed on data sets with a sample size of less than 10. The resulting UCLs for these data sets would be viewed with less certainty than UCLs calculated from larger data sets, but as described above, we were unable to achieve the sample size we desired for every sample type or compound. Additionally, there were multiple data sets for which all of the samples were reported to be below the detection limit. Some of these data sets had varying detection limits which made choosing a single value problematic. To circumvent this problem, data sets that had variability due to varying detection limits also had UCLs estimated, even if the frequency of detection was 0%. These estimated UCLs were identified as theoretical values because the mean that was calculated, from which the UCL was derived, was based only upon the detection limit and it does not include actual detected concentrations. The resulting theoretical UCL for these data sets is generally near the highest detection limit that was used.

Conclusions

The evaluation of the data collected from this Study was able to:

- provide estimates of baseline levels or background concentrations of compounds that were identified as COPCs related to the World Trade Center collapse,

- show that the estimated background concentrations were consistent with other background studies and historical data, when comparison data were available

- provide a upper-bound point estimate that can be used as a background concentration for the COPC report, and

- provide a source of data to help address data gaps in the scientific literature on background concentrations of building-related materials.

REFERENCES

(* indicates cited in text)

*ATSDR. 1995. Toxicological Profile for Polycyclic Aromatic Hydrocarbons. Atlanta, GA. Agency for Toxic Substances and Disease Registry.

*ATSDR. 1998. Toxicological Profile for Chlorinated Dibenzo-p-Dioxins. Atlanta, GA Agency for Toxic Substances and Disease Registry

*ATSDR. 1999. Toxicological Profile for Lead. Atlanta, GA: Agency for Toxic Substances and Disease Registry.

*ATSDR. 2001. Toxicological Profile for Asbestos. Atlanta, GA. Agency for Toxic Substances and Disease Registry.

*ATSDR 2002. Toxicological Profile for Synthetic Vitreous Fibers (Draft for Pubic Comment). Atlanta, GA: Agency for Toxic Substances and Disease Registry.

ATSDR. 2002a. Technical Briefing Paper: Health Effects from Exposure to Fibrous Glass, Rock Wool or Slag Wool. Atlanta, GA· Agency for Toxic Substances and Disease Registry.

Butler JD, Butterworth V, Kellow C, et al. 1984. Some observations on the polycyclic aromatic hydrocarbon (PAH) content of surface soils in urban areas. Sci Total Environ 38:75-85.

*Carter CM, Axten CW, Byers CD, et al. 1999. Indoor airborne fiber levels of MMVF in residential and commercial buildings. Am Ind Hyg Assoc J 60(6):794-800

*Christmann W, Kloeppel KD, Partscht H, et al. 1989. PCDD/PCDF and chlorinated phenols in wood preserving formulations for household use. Chemosphere 18:861-865.

*Clark P. 1989. Standard Test Method for Sampling and Analysis of Dust for Asbestos Structures by Transmission Electron Microscopy. (Draft). Cincinnati, OH: U S Environmental Protection Agency

*CPSC. 1987. Report on the first round of air sampling of asbestos in home study. Memorandum by AM Rock Washington, DC: U.S. Consumer Products Safety Commission

*Edwards NT 1983 Polycyclic aromatic hydrocarbons (PAHs) in the terrestrial environment - a review J Environ Qual 12:427-441.

References Continued

*EPA. 1996. National Air Quality and Emissions Trends Report 1995. Washington, DC: U. S Environment Protection Agency, Office of Air Quality Planning and Standards.

*Ewing WM. 2000. Further observations of settled asbestos dust in buildings. Conference: Advances in Environmental Measurement Methods for Asbestos, 13-17 July 1997, Boulder, CO. ASTM Spec Tech Publ, No. 1342. Conshohocken, PA: American Society for Testing and Materials, 323-332.

*Gallicchio L, Sexton M, Werner ML 2002. A comparison of household lead exposure assessment methods in an old, urban community. Environ Res 89:50-57.

*HEI. 1991. Asbestos in public and commercial buildings A literature review and synthesis of current knowledge. Report of the asbestos literature review panel. Cambridge, MA: Health Effects Institute

*Huber, Alan. April 14, 2003. Personal Communication. Project Status Report: Meteorological measurements and modeling supporting risk assessment.

*HUD. 2001. National Survey of Lead and Allergens in Housing, Final Report, Volume 1 Analysis of Lead Hazards, Rev. 6. Washington, DC: U.S. Department of Housing and Urban Development, Office of Lead Hazard Control.

IARC. 1973. Certain polycyclic aromatic hydrocarbons and heterocyclic compounds Monographs on the evaluation of carcinogenic risk of the chemical to man. Vol 3 Lyon, France: World Health Organization, International Agency for Research on Cancer

Jones KC, Stratford JA, Waterhouse K, et al. 1987. Polynuclear aromatic hydrocarbons in U.K. soils: Long-term temporal trends and current levels. Trace Subst Environ Health 2:140-148.

*Lanphear BP, Emond M, Jacobs DE, Weitzman M, Tanner M, Winter NL, et al 1995. A side-by-side comparison of dust collection methods for sampling lead-contaminated house dust. Environ Res 68:114-123.

*Lanphear BP, Matte TD, Rogers J, Clickner RP, Dietz B, Bornschein RL, et al. 1998. The contribution of lead-contaminated house dust and residential soil to children's blood lead levels: a pooled analysis of 12 epidemiologic studies. Environ Res 79:51-68.

*Lee RJ, Van Orden DR, Corn M, et al. 1992. Exposure to airborne asbestos in buildings Regul Toxicol Pharmacol 16:93-107

References Continued

NYCDOHMH/ATSDR. 2002. Final Report of the Public Health Investigation to Assess Potential Exposures to Airborne and Settled Surface Dust in Residential Areas of lower Manhattan. New York City Department of Health and Mental Hygiene and Agency for Toxic Substances and Disease Registry.

ProUCL Version 2.0 Software and Users Guide. 2001. Prepared by Lockheed Martin Environmental Services for USEPA.

USEPA. 2001. Guidance for Characterizing Background Chemicals in Soil at Superfund Sites. EPA 540-R-01-003.

USEPA. 2002 Role of Background in the CERCLA Cleanup Program. OSWER 9285.6-07P.

USEPA. 2002. Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA. 1989. Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual (Part A) EPA 540-1-89-002.

*Van Orden DR, Lee RJ, Bishop KM, et al. 1995. Evaluation of ambient asbestos concentrations in buildings following the Loma Prieta Earthquake. Regul Toxicol Pharmacol 21:117-122.

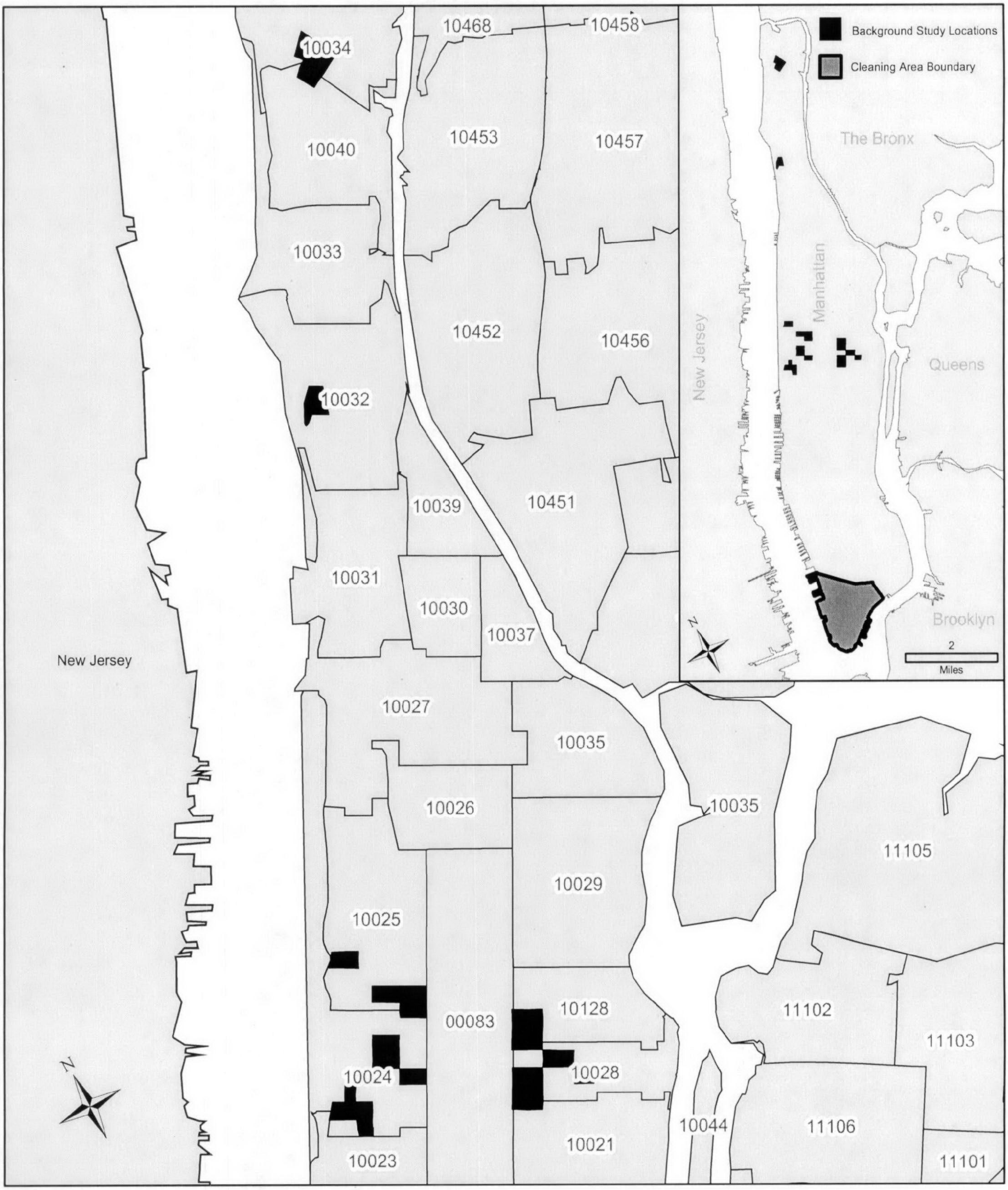
Vogt NB, Brakstad F, Thrane K, et al. 1987 Polycyclic aromatic hydrocarbons in soil and air: Statistical analysis and classification by the SIMCA method Environ Sci Technol 21:35-44.

White JB, Vanderslice RR. 1980 POM Source and Ambient Concentration Data: Review and Analysis. Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, EPA-600/7-80-044.

Windsor JG, Hites RA. 1979. Polycyclic aromatic hydrocarbons in Gulf of Maine sediments and Nova Scotia sils Geochim Cosmochim Acta 43:27-33

FIGURES

FIGURE - 1 World Trade Center Background Study and WTC Dust Cleanup Program



Generalized locations include Census Block Groups near to background study buildings.

Miles
1

TABLES

TABLE 4-1
WTC Background Study
Sampling and Analytical Procedures Summary

Media	Sampling Points	Analytical Parameters	Sampling Method	Description	Analytical Method	Required Detection Limits[1]
Settled Dust Porous Soft surfaces	Carpets, fabric furniture or drapery in areas of activity (living rooms, family rooms)	Asbestos	ASTM D 5755-95	This is a micro vacuuming method By taping three wipe-sampling templates together, three co-located samples were collected from each location	ASTM D 5755-95	1000 structures/cc
		Lead	ASTM E 1973-99	This is a micro vacuuming method By taping three wipe-sampling templates together, three co-located samples were collected from each location	SW-846 6010B	<25 ug/ft^2
Settled Dust Non-porous Hard surfaces	Horizontal surfaces of tables or counters and bare floors, ceilings and walls in areas of activity (living rooms, family rooms)	Asbestos	ASTM D 6480-99	Wipe Samples (samples will be collected on the same wipe as MMVF)	ASTM D 6480-99 (wipe)	1000 structures/cc
		Lead	HUD Appendix 13 1	Wipe Samples	SW-846 6010B	<25 ug/ft^2
		Dioxins	ASTM D 6661-01	Wipe Samples	ASTM 6661-01/SW-846 8290	<2 ng/m^2
		PAHs	ASTM D 6661-01	Wipe Samples	ASTM 6661-01/SW-846 8270C	<0 3 mg/m^2
		Total Dust	HUD Appendix 13 1[2]	Wipe Samples	No Formal Method (NIOSH 7500 Modified)	No detection limit required
		Silica, calcite, gypsum	HUD Appendix 13 1[2]	Wipe Samples All parameters were collected on one wipe	NIOSH 7500 (XRD)	Background
		MMVF	ASTM D 6480-99	Wipe Samples (samples will be collected on the same wipe as asbestos)	EMSL MSD 0310	Background
Indoor Air	Areas of known activity (living rooms, family rooms)	Asbestos	NIOSH 7400	Air pump operated at 10L/min for 8 hours to achieve the COPC wkgroup Practical Quantitation Limit (PQL)	PCM NIOSH 7400 followed by TEM AHERA method	PCM 0 0009 f/cc TEM 0 0005 f/cc
		Lead	NIOSH 7300	Air pump operated at 10L/min for 8 hours to achieve the COPC wkgroup PQL	SW-846 6010B	0 1 ug/m^3
		Silica, calcite, gypsum	NIOSH 7500	Air pump operated at 2 5L/min for 8 hours to achieve the COPC wkgroup PQL	NIOSH 7500 (XRD)	0 5 ug/m^3
		MMVF[3]	NIOSH 7400	Air pump operated at 10L/min for 8 hours to achieve the COPC wkgroup Practical Quantitation Limit (PQL)	EMSL MSD 0310	<0 01 f/cc
Bulk Dust	AC window units (collection of bulk dust sample from the unit air filters)	Asbestos, lead, silica, calcite, gypsum, MMVF	Attachment 5 of the QAPP "HVAC Or Air Conditioner Filter Bulk Collection Protocol" prepared by TRC Solutions Inc	Bulk dust samples[4] were collected from AC window type unit filters, brushed with a disposable brush into a stainless steel bowl and transferred into sample containers If the volume required was not sufficient for all analyses, the sample analysis was prioritized as follows asbestos, lead, silica, calcite, gypsum, MMVF, PAHs, and dioxins	**Asbestos** PLM NYS 198 1 followed by TEM NYS 198 4	Background
					Lead SW-846 6010B	<25 ug/ft^2
					Silica, calcite, gypsum NIOSH 7500 (XRD)	Background
					MMVF: PLM NYS 198 1/EMSL MSD 0310	Background
		Dioxins, PAHs			**Dioxins**· SW-846 8290	<2 ng/m^2
					PAHs· SW-846 8270	<0 3 mg/m^2

NOTES
[1]Required Detection limits are Tier III Levels from "Indoor Air Assessment Selecting Contaminants of Potential Concern and Setting Health Based Benchmarks" prepared by the Contaminants of Potential Concern (COPC) Committee of the World Trade Center Indoor Air Taskforce Working Group
[2] Wipe samples for total dust and silica, calcite and gypsum will be collected using the HUD Appendix 13 1 method since no standardized method is available
[3] No standardized sampling method exists for this parameter On the assumption that this fibrous material behaves in the air in the same way as asbestos, NIOSH 7400 will be utilized Analysis via EMSL MSD 0310 (see the EMSL SOP in Appendix C)
[4] No less than 5 grams and up to 20 grams of dust are required to analyze for asbestos, lead, silica, calcite, gypsum, and MMVF At least 10 grams of dust for PAHs and 30 grams for dioxins

LEGEND
< = less than
f/cc = fibers per square centimeter
mg/m^2 = milligrams per square meter
ng/m^2 = nanograms per square meter
ug/ft^2 = micrograms per square foot
ug/m^3 = micrograms per square meter

TABLE 4-2
WTC Background Study
Field Sample Collection Summary

Analytical Parameters	Matrix	Sample Media / Container	Preservative	Holding Time From Date of Sampling	Samples Collected	Quality Control Samples Collected: Lot blanks	Field Blanks	Spike Blanks	Duplicate Samples	Total Field Samples
Asbestos	Microvacuum	0 45 um MCEF 25 mm	20°C (None)	Unlimited	162	14	28	0	*	204
Lead	Microvacuum	0 8 um MCEF 37 mm	20°C (None)	6 months	162	14	28	0	*	204
Asbestos / MMVF	Wipe	9 x 9 inch Cleanroom Wipe	20°C (None)	Unlimited	146	14	28	0	14	202
Lead	Wipe	15 x 15 cm Ghost Wipes	20°C (None)	6 months	114	14	14	14**	14	170
Dioxins	Wipe	3 x 3 inch cotton gauze	4°C	7 days to extraction, 40 days to analysis	114	14	14	0	14	156
PAHs	Wipe	3 x 3 inch cotton gauze	4°C	7 days to extraction, 40 days to analysis	113	14	14	0	14	155
Total Dust	Wipe	15 x 15 cm Ghost Wipes	20°C (None)	Unlimited	35	14	14	0	3	66
Silica, calcite, gypsum	Wipe	15 x 15 cm Ghost Wipes	20°C (None)	28 days	114	14	14	0	14	156
Asbestos / MMVF	Air	0 45 um MCEF 25 mm	20°C (None)	Unlimited	64	13	28	0	32	137
Lead	Air	0 8 um MCEF 37 mm	20°C (None)	6 months	46	14	29	0	14	103
Silica, calcite, gypsum	Air	5 um PVC filter 37 mm	20°C (None)	28 days	46	14	28	0	14	102
Asbestos / MMVF	Bulk Dust	4 oz. Polypropylene	20°C (None)	Unlimited	24	NC	NC	NC	NC	24
Lead	Bulk Dust	4 oz Polypropylene	20°C (None)	6 months	9	NC	NC	NC	NC	9
Dioxins	Bulk Dust	125 ml Amber Glass	4°C	7 days	NC	NC	NC	NC	NC	0
PAHs	Bulk Dust	125 ml Amber Glass	4°C	7 days to extraction, 40 days to analysis	NC	NC	NC	NC	NC	0
Silica, calcite, gypsum	Bulk Dust	4 oz Polypropylene	20°C (None)	28 days	9	NC	NC	NC	NC	9

NOTES:
The information provided in this table represents the number of samples and QC samples collected It is not an indication of the number of sample analytical results reported since several samples were collected for multiple analytes
NC = QC Sample was not collected due to insufficient material.
* Microvacuum samples were collected as co-located triplicate samples therefore duplicate samples were not collected.
** As recommended in the method, spike samples were prepared and submitted with the wipe samples into the sampling stream for lead analysis only

Table 4-3

Quality Control Wipe Spike Sample Results For Lead

Sample Identification Number	Spike Added (g)	True Value (ug/wipe) +- 2%	Spike Sample Results[1] (ug/wipe)	Percent Recovery	QC Limit % Recovery
13-BG-Common Area-Wipe Ceiling 1-L	0.0919	413	361	87%	80-120%
10-BG-Common Area-Wipe Ceiling 1-L	0.1018	457	397	87%	80-120%
11-BG-Common Area-Wipe Ceiling 1-L	0.0997	448	405	90%	80-120%
14-BG-Common Area-Wipe Ceiling 1-L	0.1063	477	414	87%	80-120%
9-BG-Common Area-Wipe Ceiling 1-L	0.1031	463	404	87%	80-120%
4-BG-Wipe Ceiling 1-L	0.0572	257	219	85%	80-120%
2-BG-Common Area-Wipe Ceiling 1-L	0.0530	238	189	**79%**	80-120%
8-BG-Wipe Ceiling 1-L	0.0956	429	432	101%	80-120%
3-BG-Wipe Ceiling 1-L	0.0602	270	209	**78%**	80-120%
5-BG-Wipe Ceiling 1-L	0.0504	226	205	91%	80-120%
1-BG-Common Area-Wipe Ceiling 1-L	0.0540	242	202	83%	80-120%
6-BG-Wipe Ceiling 1-L	0.0708	318	289	91%	80-120%
7-BG-Common Area-Wipe Ceiling 1-L	0.0681	306	294	96%	80-120%
12-BG-Common Area-Wipe Ceiling 1-L	0.0982	441	ND[2]	-	80-120%

1 Result of the spike sample sent indistinguishably to the lab with field samples

2 It is believed this sample was inadvertently switched at the laboratory with a counter wipe sample The laboratory could not confirm this result, although the result of the counter wipe was 383 ug/ft^{2}, where as the ceiling wipe sample was not detected.

Table 6-1. Summary of the analytical results for the organic and inorganic compounds from the background study. The table presents the sample size, frequency of detection, minimum and maximum detected concentrations, arithmetic mean, the statistic used, and the upper confidence limit (UCL) for each compound and matrix sampled. The values in this table were calculated using the entire data set for each analyte, which includes residential and common areas.

Total Data Set		**n**	**Freq. Of Detection**	**Range**		**Arithmetic Mean**	**Statistic**	**UCL**
Analyte	**Matrix**			**Minimum***	**Maximum**			
Asbestos	Bulk Dust	3	0/3	<0.5%	--------	--------	--------	--------
	Air - PCM	64	33/64	0.0005 f/cc	0.007 f/cc	0.0017 f/cc	95% Chebyshev (Mean, STD)	0.0027 f/cc
	Air - TEM AHERA	62	4/62	0.0002 s/cc	0.0004 s/cc	0.00022 s/cc	95% Chebyshev (Mean, STD)	0.00025 s/cc
	Air - TEM PCMe	62	3/62	0 0002 s/cc	0.0004 s/cc	0.00022 s/cc	95% Chebyshev (Mean, STD)	0.00024 s/cc
	Microvacuum - All	161	21/161	317 s/cm^2	72,094 s/cm^2	2,783 s/cm^2		
	Microvacuum - Carpet	69	13/69	317 s/cm^2	72,094 s/cm^2	3,715 s/cm^2		
	Microvacuum - Couch	77	6/77	317 s/cm^2	24,138 s/cm^2	1,818 s/cm^2		
	Wipe - All	146	25/146	592 s/cm^2	3,798,910 s/cm^2	37,174 s/cm^2	97.5% Chebyshev (Mean, STD)	207,033 s/cm^2

*Minimum detected value includes values that may be ½ of the detection limit

Total Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	Matrix			Minimum*	Maximum			
	Wipe - Ceiling	32	4/32	592 s/cm^2	83,893 s/cm^2	3,885 s/cm^2	97.5% Chebyshev (Mean, STD)	20,109 s/cm^2
	Wipe - Counter	32	6/32	592 s/cm^2	1,183,205 s/cm^2	37,910 s/cm^2	97.5% Chebyshev (Mean, STD)	268,632 s/cm^2
	Wipe - Floors	34	8/34	592 s/cm^2	3,798,910 s/cm^2	113,999 s/cm^2	97.5% Chebyshev (Mean, STD)	811,379 s/cm^2
	Wipe - Walls	48	7/34	592 s/cm^2	149,055 s/cm^2	4,460 s/cm^2	97.5% Chebyshev (Mean, STD)	23,762 s/cm^2
MMVF	Bulk Dust	24	0/24	<0.5 %	--------	--------	--------	--------
	Air	62	5/62	0.032 s/L	0.216 s/L	0.042 s/L	95% Chebyshev (Mean, STD)	0.06 s/L
	Wipe - All	141	14/141	29 s/cm^2	286 s/cm^2	38 s/cm^2	95% Chebyshev (Mean, STD)	52 s/cm^2
	Wipe - Ceiling	31	1/31	29 s/cm^2	286 s/cm^2	37 s/cm^2	95% Chebyshev (Mean, STD)	73 s/cm^2
	Wipe - Counter	31	1/31	29 s/cm^2	114 s/cm^2	31 s/cm^2	95% Chebyshev (Mean, STD)	43 s/cm^2

*Minimum detected value includes values that may be ½ of the detection limit

Table 6-1

Total Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	**Matrix**			**Minimum***	**Maximum**			
	Wipe - Floors	33	11/33	29 s/cm^2	286 s/cm^2	59 s/cm^2	95% Chebyshev (Mean, STD)	103 s/cm^2
	Wipe - Walls	46	1/46	29 s/cm^2	57 s/cm^2	29 s/cm^2	95% Chebyshev (Mean, STD)	32 s/cm^2
Lead	Bulk Dust	9	9/9	44.5 mg/kg	242 mg/kg	126 mg/kg	95% H-UCL	186 mg/kg
	Air	46	1/46	0.026 µg/m^3	0.058 µg/m^3	0.027 µg/m^3	95% Chebyshev (Mean, STD)	0.03 µg/m^3
	Microvacuum - All	162	13/162	1.16 µg/ft^2	9.73 µg/ft^2	1.51 µg/ft^2	95% Chebyshev (Mean, STD)	1.98 µg/ft^2
	Microvacuum - Carpet	69	10/69	1 16 µg/ft^2	9.73 µg/ft^2	1.89 µg/ft^2	95% Chebyshev (Mean, STD)	2.94 µg/ft^2
	Microvacuum - Couch	78	3/78	1.16 µg/ft^2	3.6 µg/ft^2	1.23 µg/ft^2	95% Chebyshev (Mean, STD)	1.41 µg/ft^2
	Wipe - All	114	57/114	0.25 µg/ft^2	49.2 µg/ft^2	1.75 µg/ft^2	97.5% Chebyshev (Mean, STD)	4.59 µg/ft^2
	Wipe - Counter	32	15/32	0.25 µg/ft^2	7 µg/ft^2	1.17 µg/ft^2	97.5% Chebyshev (Mean, STD)	3.07 µg/ft^2

*Minimum detected value includes values that may be ½ of the detection limit

Table 6-1

Total Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	Matrix			Minimum*	Maximum			
	Wipe - Floors	34	30/34	0.25 µg/ft^2	49.2 µg/ft^2	3.91 µg/ft^2	97.5% Chebyshev (Mean, STD)	12.9 µg/ft^2
	Wipe - Walls	48	12/48	0.25 µg/ft^2	4.48 µg/ft^2	0.61 µg/ft^2	95% Chebyshev (Mean, STD)	1.18 µg/ft^2
Dioxin (TEQ EMPC (ND=1/2)	Wipe - All	114	88/114	0.475 ng/m^2	1.66 ng/m^2	0.644 ng/m^2	95% Chebyshev (Mean, STD)	0.693 ng/m^2
	Wipe - Counter	32	23/32	0.475 ng/m^2	0.823 ng/m^2	0.641 ng/m^2	95% H-UCL	0.669 ng/m^2
	Wipe - Floors	34	26/34	0.546 ng/m^2	0.791 ng/m^2	0.633 ng/m^2	95% Chebyshev (Mean, STD)	0.684 ng/m^2
	Wipe - Walls	48	39/48	0.518 ng/m^2	1.66 ng/m^2	0.653 ng/m^2	95% Chebyshev (Mean, STD)	0.756 ng/m^2
PAH - TEF	Wipe - All	113	0/113	290 µg/m^2	--------	--------	--------	--------
	Wipe - Counter	31	0/31	290 µg/m^2	--------	--------	--------	--------
	Wipe - Floors	34	0/34	290 µg/m^2	--------	--------	--------	--------
	Wipe - Walls	48	0/48	290 µg/m^2	--------	--------	--------	--------

*Minimum detected value includes values that may be ½ of the detection limit

Table 6-1

Table 6-2. Summary of the analytical results for the organic and inorganic compounds from the background study. The table presents the sample size, frequency of detection, minimum and maximum detected concentrations, arithmetic mean, and the statistic used, and the upper confidence limit (UCL) for each compound and matrix sampled. The values in this table were calculated using only the data sets from the residence areas for each analyte.

Residential Data Set		**n**	**Freq. Of Detection**	**Range**		**Arithmetic Mean**	**Statistic**	**UCL**
Analyte	**Matrix**			**Minimum***	**Maximum**			
Asbestos	Bulk Dust	3	0/3	<0.5%	--------	--------	--------	--------
	Air - PCM	50	21/50	0.0005 f/cc	0 007 f/cc	0.0014 f/cc	95% Chebyshev (Mean, STD)	0.0023 f/cc
	Air - TEM AHERA	48	2/48	0.0002 s/cc	0.0004 s/cc	0.00022 s/cc	95% Chebyshev (Mean, STD)	0.00024 s/cc
	Air - TEM PCMe	48	2/48	0.0002 s/cc	0.0004 s/cc	0.00022 s/cc	95% Chebyshev (Mean, STD)	0.00024 s/cc
	Microvacuum - All	143	15/143	317 s/cm^2	72,094 s/cm^2	2,234 s/cm^2		
	Microvacuum - Carpet	60	10/60	317 s/cm^2	72,094 s/cm^2	2,861 s/cm^2		
	Microvacuum - Couch	71	4/71	317 s/cm^2	24,138 s/cm^2	1,732 s/cm^2		
	Microvacuum - Drapes	12	1/12	791 s/cm^2	12,288 s/cm^2	2,071 s/cm^2	95% Chebyshev (Mean, STD)	6,149 s/cm^2
	Wipe - All	104	14/104	592 s/cm^2	83,893 s/cm^2	2,309 s/cm^2	95% Chebyshev (Mean, STD)	6,192 s/cm^2
	Wipe - Ceiling	24	3/24	592 s/cm^2	83,893 s/cm^2	4,683 s/cm^2	97.5% Chebyshev (Mean, STD)	26,295 s/cm^2

* Minimum detected value includes values that may be ½ of the detection limit

Residential Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	Matrix			Minimum*	Maximum			
	Wipe - Counter	25	3/25	592 s/cm^2	2,770 s/cm^2	870 s/cm^2	95% Chebyshev (Mean, STD)	1,357 s/cm^2
	Wipe - Floors	25	4/25	592 s/cm^2	40,363 s/cm^2	2,405 s/cm^2	95% Chebyshev (Mean, STD)	9,307 s/cm^2
	Wipe - Walls	30	4/30	592 s/cm^2	12,267 s/cm^2	1,530 s/cm^2	95% Chebyshev (Mean, STD)	3,473 s/cm^2
MMVF	Bulk Dust	24	0/24	<0.5%	--------	--------	--------	--------
	Air	48	1/48	0.032 s/L	0 216 s/L	0.041 s/L	95% Chebyshev (Mean, STD)	0.06 s/L
	Wipe - All	99	11/99	29 s/cm^2	286 s/cm^2	38 s/cm^2	95% Chebyshev (Mean, STD)	53 s/cm^2
	Wipe - Ceiling	23	1/23	29 s/cm^2	286 s/cm^2	40 s/cm^2	95% Chebyshev (Mean, STD)	87 s/cm^2
	Wipe - Counter	24	1/24	29 s/cm^2	114 s/cm^2	32 s/cm^2	95% Chebyshev (Mean, STD)	48 s/cm^2
	Wipe - Floors	24	8/24	29 s/cm^2	172 s/cm^2	52 s/cm^2	95% Chebyshev (Mean, STD)	89 s/cm^2
	Wipe - Walls	28	1/28	29 s/cm^2	57 s/cm^2	30 s/cm^2	95% Chebyshev (Mean, STD)	34 s/cm^2
Lead	Bulk Dust	9	9/9	44.5 mg/kg	242 mg/kg	126 mg/kg	95% H-UCL	186 mg/kg

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-2

Residential Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	**Matrix**			**Minimum***	**Maximum**			
	Air	32	1/32	0.026 $\mu g/m^3$	0.058 $\mu g/m^3$	0.028 $\mu g/m^3$	95% Chebyshev (Mean, STD)	0.032 $\mu g/m^3$
	Microvacuum - All	144	12/144	1.16 $\mu g/ft^2$	9.73 $\mu g/ft^2$	1.53 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	2.05 $\mu g/ft^2$
	Microvacuum - Carpet	60	10/60	1.16 $\mu g/ft^2$	9.73 $\mu g/ft^2$	2.00 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	3.20 $\mu g/ft^2$
	Microvacuum - Couch	72	2/72	1.16 $\mu g/ft^2$	2.83 $\mu g/ft^2$	1.20 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	1.34 $\mu g/ft^2$
	Microvacuum - Drapes	12	0/12	1.16 $\mu g/ft^2$	--------	--------	--------	--------
	Wipe - All	80	39/80	0.25 $\mu g/ft^2$	10.5 $\mu g/ft^2$	1 04 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	1.78 $\mu g/ft^2$
	Wipe - Counter	25	12/25	0.25 $\mu g/ft^2$	5.9 $\mu g/ft^2$	1.1 $\mu g/ft^2$	97.5% Chebyshev (Mean, STD)	2.98 $\mu g/ft^2$
	Wipe - Floors	25	21/25	0.25 $\mu g/ft^2$	10.5 $\mu g/ft^2$	1 82 $\mu g/ft^2$	95% H-UCL	2.96 $\mu g/ft^2$
	Wipe - Walls	30	6/30	0.25 $\mu g/ft^2$	1.01 $\mu g/ft^2$	0.35 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	0.52 $\mu g/ft^2$
Dioxin	Wipe - All	80	19/80	0.475 ng/m^2	0.83 ng/m^2	0.629 ng/m^2	95% H-UCL	0.643 ng/m^2
	Wipe - Counter	25	6/25	0.475 ng/m^2	0.823 ng/m^2	0.639 ng/m^2	95% H-UCL	0.672 ng/m^2
	Wipe - Floors	25	6/25	0.546 ng/m^2	0.771 ng/m^2	0.621 ng/m^2	Student's t	0.643 ng/m^2
	Wipe - Walls	30	7/30	0.534 ng/m^2	0.83 ng/m^2	0 628 ng/m^2	95% H-UCL	0.650 ng/m^2

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-2

Residential Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	Matrix			Minimum*	Maximum			
PAH	Wipe - All	80	0/80	290 µg/m^2	--------	---------	--------	--------
	Wipe - Counter	25	0/25	290 µg/m^2	--------	---------	--------	--------
	Wipe - Floors	25	0/25	290 µg/m^2	--------	---------	--------	--------
	Wipe - Walls	30	0/30	290 µg/m^2	--------	---------	--------	--------

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-2

Table 6-3. Summary of the analytical results for the organic and inorganic compounds from the background study. The table presents the sample size, frequency of detection, minimum and maximum detected concentrations, arithmetic mean, the statistic used, and the upper confidence limit (UCL) for each compound and matrix sampled. The values in this table were calculated using only the data sets from the common areas for each analyte.

Common Area Data Set		**n**	**Freq. Of Detection**	**Range**		**Arithmetic Mean**	**Statistic**	**UCL**
Analyte	**Matrix**			**Minimum***	**Maximum**			
Asbestos	Bulk Dust	0	--------	--------	--------	--------	---------	--------
	Air - PCM	14	10/14	0.0005 f/cc	0.007 f/cc	0.0028 f/cc	95% Chebyshev (Mean, STD)	0.0058 f/cc
	Air - TEM AHERA	14	2/14	0.0002 s/cc	0.0004 s/cc	0.00024 s/cc	95% Chebyshev (Mean, STD)	0.00032 s/cc
	Air - TEM PCMe	14	1/14	0.0002 s/cc	0.0004 s/cc	0.00023 s/cc	95% Chebyshev (Mean, STD)	0.00029 s/cc
	Microvacuum - All	18	6/18	792 s/cm^2	61,732 s/cm^2	7,145 s/cm^2		
	Microvacuum - Carpet	9	3/9	792 s/cm^2	61,732 s/cm^2	9,409 s/cm^2		
	Microvacuum - Chair	3	1/3	1,979 s/cm^2	22,952 s/cm^2	8,970 s/cm^2		
	Microvacuum - Couch	6	2/6	792 s/cm^2	9,497 s/cm^2	2,836 s/cm^2		
	Wipe - All	42	11/42	592 s/cm^2	3,798,910 s/cm^2	123,507 s/cm^2	97.5% Chebyshev (Mean, STD)	710,495 s/cm^2

* Minimum detected value includes values that may be ½ of the detection limit

Common Area Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	Matrix			Minimum*	Maximum			
	Wipe - Ceiling	8	1/8	592 s/cm^2	5,916 s/cm^2	1,492 s/cm^2	95% Chebyshev (Mean, STD)	4,319 s/cm^2
	Wipe - Counter	7	3/7	592 s/cm^2	1,183,205 s/cm^2	170,193 s/cm^2	99% Chebyshev (Mean, STD)	1,850,087 s/cm^2
	Wipe - Floors	9	4/9	592 s/cm^2	3,798,910 s/cm^2	423,979 s/cm^2	99% Chebyshev (Mean, STD)	4,621,507 s/cm^2
	Wipe - Walls	18	3/18	592 s/cm^2	149,055 s/cm^2	9,344 s/cm^2	97.5% Chebyshev (Mean, STD)	60,698 s/cm^2
MMVF	Bulk Dust	0	--------	--------	--------	--------	--------	--------
	Air	14	4/14	0.032 s/L	0.196 s/L	0.0452 s/L	95% Chebyshev (Mean, STD)	0.096 s/L
	Wipe - All	42	3/42	29 s/cm^2	286 s/cm^2	39 s/cm^2	95% Chebyshev (Mean, STD)	69 s/cm^2
	Wipe - Ceiling	8	0/8	29 s/cm^2	--------	--------	--------	--------
	Wipe - Counter	7	0/7	29 s/cm^2	--------	--------	--------	--------

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-3

Common Area Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	**Matrix**			**Minimum***	**Maximum**			
	Wipe - Floors	9	3/9	29 s/cm^2	286 s/cm^2	76 s/cm^2	95% Chebyshev (Mean, STD)	209 s/cm^2
	Wipe - Walls	18	0/18	29 s/cm^2	--------	--------	--------	--------
Lead	Bulk Dust	0	--------	--------	--------	--------	--------	--------
	Air	14	0/14	0.026 µg/m^3	0.027 µg/m^3	0.026 µg/m^3	95% Chebyshev (Mean, STD)	0.027 µg/m^3
	Microvacuum - All	18	1/18	1.16 µg/ft^2	3.6 µg/ft^2	1.30 µg/ft^2	95% Chebyshev (Mean, STD)	1.89 µg/ft^2
	Microvacuum - Carpet	9	0/9	1.16 µg/ft^2	--------	--------	--------	--------
	Microvacuum - Chair	3	0/3	1.16 µg/ft^2	--------	--------	--------	--------
	Microvacuum - Couch	6	1/6	1.16 µg/ft^2	3.6 µg/ft^2	1.57 µg/ft^2	95% Chebyshev (Mean, STD)	3.34 µg/ft^2
	Wipe - All	34	18/34	0.25 µg/ft^2	49.2 µg/ft^2	3.42 µg/ft^2	97.5% Chebyshev (Mean, STD)	12.44 µg/ft^2

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-3

Common Area Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	**Matrix**			**Minimum***	**Maximum**			
	Wipe - Counter	7	3/7	0.25 µg/ft^2	7 µg/ft^2	1.39 µg/ft^2	97.5% Chebyshev (Mean, STD)	7.28 µg/ft^2
	Wipe - Floors	9	9/9	2.3 µg/ft^2	49.2 µg/ft^2	9.74 µg/ft^2	95% Chebyshev (Mean, STD)	31.44 µg/ft^2
	Wipe - Walls	18	6/18	0.25 µg/ft^2	4.48 µg/ft^2	1.04 µg/ft^2	97.5% Chebyshev (Mean, STD)	3.05 µg/ft^2
Dioxin	Wipe - All	34	7/34	0.518 ng/m^2	1.66 ng/m^2	0.677 ng/m^2	95% Chebyshev (Mean, STD)	0.817 ng/m^2
	Wipe - Counter	7	3/7	0.53 ng/m^2	0.709 ng/m^2	0.648 ng/m^2	95% Chebyshev (Mean, STD)	0.767 ng/m^2
	Wipe - Floors	9	2/9	0.57 ng/m^2	0.791 ng/m^2	0.665 ng/m^2	95% H-UCL	0.716 ng/m^2
	Wipe - Walls	18	2/18	0.518 ng/m^2	1.66 ng/m^2	0.694 ng/m^2	95% Chebyshev (Mean, STD)	0.951 ng/m^2
PAH	Wipe - All	33	0/33	290 µg/m^2	--------	--------	--------	--------
	Wipe - Counter	6	0/6	290 µg/m^2	--------	--------	--------	--------

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-3

Common Area Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Analyte	Matrix			Minimum*	Maximum			
	Wipe - Floors	9	0/9	290 µg/m^2	--------	--------	--------	--------
	Wipe - Walls	18	0/18	290 µg/m^2	--------	--------	--------	--------

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-3

Table 6-4. Summary of the analytical results for the mineral compounds and total dust from the background study. The table presents the sample size, frequency of detection, minimum and maximum detected concentrations, arithmetic mean, the statistic used, and the upper confidence limit (UCL) for each compound and matrix sampled. The values in this table were calculated using the entire data set for each analyte, which includes residential and common areas.

Total Data Set		**n**	**Freq. Of Detection**	**Range**		**Arithmetic Mean**	**Statistic**	**UCL**
Anaylte	**Matrix**			**Minimum***	**Maximum**			
Alpha-quartz	Bulk Dust	9	8/9	1.01 %	6.89 %	2.2 %	95% H-UCL	3.66 %
	Air	46	12/46	2 μg/m³	259 μg/m³	9.2 μg/m³	95% Chebyshev (Mean, STD)	33.5 μg/m³
	Wipe - All	114	51/114	12.5 μg/ft²	1880 μg/ft²	79.5 μg/ft²	95% Chebyshev (Mean, STD)	156.3 μg/ft²
	Wipe - Counter	32	13/32	12.5 μg/ft²	370 μg/ft²	67.0 μg/ft²	95% Chebyshev (Mean, STD)	134.7 μg/ft²
	Wipe - Floors	34	20/34	25 μg/ft²	1880 μg/ft²	125.4 μg/ft²	95% Chebyshev (Mean, STD)	367.9 μg/ft²
	Wipe - Walls	48	18/48	12.5 μg/ft²	270 μg/ft²	55.3 μg/ft²	95% Chebyshev (Mean, STD)	94.1 μg/ft²
Calcite	Bulk Dust	9	1/9	0.425 %	4.95 %	1.56 %	95% H-UCL	3.41 %
	Air	46	0/46	8 μg/m³	11 μg/m³	8.8 μg/m³	95% Chebyshev (Mean, STD)	9.3 μg/m³
	Wipe - All	114	3/114	50 μg/ft²	785 μg/ft²	102.6 μg/ft²	95% Chebyshev (Mean, STD)	132.3 μg/ft²
	Wipe - Counter	32	0/32	50 μg/ft²	100 μg/ft²	92.2 μg/ft²	95% Chebyshev (Mean, STD)	106.4 μg/ft²
	Wipe - Floors	33	2/33	50 μg/ft²	350 μg/ft²	104.8 μg/ft²	95% Chebyshev (Mean, STD)	147.2 μg/ft²
	Wipe - Walls	49	1/49	50 μg/ft²	785 μg/ft²	107.9 μg/ft²	95% Chebyshev (Mean, STD)	170.2 μg/ft²
Cristobalite	Bulk Dust	9	0/9	0.04 %	4.95 %	1.45 %	97.5% Chebyshev (Mean, STD)	4.69 %
	Air	46	0/46	8 μg/m³	11 μg/m³	8.8 μg/m³	95% Chebyshev (Mean, STD)	9.3 μg/m³

* Minimum detected value includes values that may be ½ of the detection limit

Total Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Anaylte	Matrix			Minimum*	Maximum			
	Wipe - All	114	1/114	50 $\mu g/ft^2$	260 $\mu g/ft^2$	93.9 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	103.7 $\mu g/ft^2$
	Wipe - Counter	32	0/32	50 $\mu g/ft^2$	100 $\mu g/ft^2$	92.2 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	106.4 $\mu g/ft^2$
	Wipe - Floors	33	1/33	50 $\mu g/ft^2$	260 $\mu g/ft^2$	97.3 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	123.4 $\mu g/ft^2$
	Wipe - Walls	49	0/49	50 $\mu g/ft^2$	100 $\mu g/ft^2$	92.9 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	103.9 $\mu g/ft^2$
Gypsum	Bulk Dust	9	1/9	0.02 %	2.38 %	0.76 %	97.5 Chebyshev (Mean, STD)	2.33 %
	Air	46	0/46	4 $\mu g/m^3$	5.5 $\mu g/m^3$	4.25 $\mu g/m^3$	95% Chebyshev (Mean, STD)	4.54 $\mu g/m^3$
	Wipe - All	114	0/114	25 $\mu g/ft^2$	50 $\mu g/ft^2$	46.3 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	49.9 $\mu g/ft^2$
	Wipe - Counter	32	0/32	25 $\mu g/ft^2$	50 $\mu g/ft^2$	46.7 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	53 2 $\mu g/ft^2$
	Wipe - Floors	33	0/33	25 $\mu g/ft^2$	50 $\mu g/ft^2$	46.2 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	53.1 $\mu g/ft^2$
	Wipe - Walls	49	0/49	25 $\mu g/ft^2$	50 $\mu g/ft^2$	46.4 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	51.9 $\mu g/ft^2$
Portlandite	Bulk Dust	9	0/9	0.04 %	4.95 %	1.45 %	97.5% Chebyshev (Mean, STD)	4.69 %
	Air	46	0/46	8 $\mu g/m^3$	11 $\mu g/m^3$	8.8 $\mu g/m^3$	95% Chebyshev (Mean, STD)	9.3 $\mu g/m^3$
	Wipe - All	114	0/114	50 $\mu g/ft^2$	100 $\mu g/ft^2$	92.5 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	99.8 $\mu g/ft^2$
	Wipe - Counter	32	0/32	50 $\mu g/ft^2$	100 $\mu g/ft^2$	92.2 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	106.4 $\mu g/ft^2$
	Wipe - Floors	33	0/33	50 $\mu g/ft^2$	100 $\mu g/ft^2$	92.4 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	106.2 $\mu g/ft^2$
	Wipe - Walls	49	0/49	50 $\mu g/ft^2$	100 $\mu g/ft^2$	92.9 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	103.9 $\mu g/ft^2$
Tridymite	Bulk Dust	9	0/9	0.04 %	4.95 %	1.45 %	97.5% Chebyshev (Mean, STD)	4.69 %

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-4

Total Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Anaylte	**Matrix**			**Minimum***	**Maximum**			
	Air	46	0/46	8 µg/m^3	11 µg/m^3	8.8 µg/m^3	95% Chebyshev (Mean, STD)	9.3 µg/m^3
	Wipe - All	114	0/114	50 µg/ft^2	100 µg/ft^2	92.5 µg/ft^2	95% Chebyshev (Mean, STD)	99.8 µg/ft^2
	Wipe - Counter	32	0/32	50 µg/ft^2	100 µg/ft^2	92.2 µg/ft^2	95% Chebyshev (Mean, STD)	106.4 µg/ft^2
	Wipe - Floors	33	0/33	50 µg/ft^2	100 µg/ft^2	92.4 µg/ft^2	95% Chebyshev (Mean, STD)	106.2 µg/ft^2
	Wipe - Walls	49	0/49	50 µg/ft^2	100 µg/ft^2	92.9 µg/ft^2	95% Chebyshev (Mean, STD)	103.9 µg/ft^2
Total Dust	Wipe	35	35/35	0.366 mg/ft^2	18.1 mg/ft^2	10.9 mg/ft^2	95% Chebyshev (Mean, STD)	14.4 mg/ft^2

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-4

Table 6-5. Summary of the analytical results for the mineral compounds and total dust from the background study. The table presents the sample size, frequency of detection, minimum and maximum detected concentrations, arithmetic mean, the statistic used, and the upper confidence limit (UCL) for each compound and matrix sampled. The values in this table were calculated using only the data sets from the residence areas for each analyte.

Residential Data Set		**n**	**Freq. Of Detection**	**Range**		**Arithmetic Mean**	**Statistic**	**UCL**
Anaylte	**Matrix**			**Minimum***	**Maximum**			
Alpha-quartz	Bulk Dust	9	8/9	1.01 %	6.89 %	2.2 %	95% H-UCL	3.66 %
	Air	32	8/32	2 µg/m³	259 µg/m³	11 8 µg/m³	97.5% Chebyshev (Mean, STD)	61.9 µg/m³
	Wipe - All	81	31/81	12.5 µg/ft²	370 µg/ft²	50.8 µg/ft²	95% Chebyshev (Mean, STD)	79.6 µg/ft²
	Wipe - Counter	25	10/25	12.5 µg/ft²	370 µg/ft²	67.5 µg/ft²	95% Chebyshev (Mean, STD)	148.4 µg/ft²
	Wipe - Floors	26	13/26	25 µg/ft²	180 µg/ft²	54.0 µg/ft²	95% Chebyshev (Mean, STD)	91 1 µg/ft²
	Wipe - Walls	30	8/30	12.5 µg/ft²	110 µg/ft²	34.2 µg/ft²	95% Chebyshev (Mean, STD)	51.6 µg/ft²
Calcite	Bulk Dust	9	1/9	0.425 %	4.95 %	1.56 %	95% H-UCL	3.41 %
	Air	32	0/32	8 µg/m³	11 µg/m³	8.78 µg/m³	95% Chebyshev (Mean, STD)	9.4 µg/m³
	Wipe - All	80	2/80	50 µg/ft²	785 µg/ft²	104.2 µg/ft²	95% Chebyshev (Mean, STD)	145.2 µg/ft²

* Minimum detected value includes values that may be ½ of the detection limit

Residential Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Anaylte	Matrix			Minimum*	Maximum			
	Wipe - Counter	25	0/25	50 µg/ft^2	100 µg/ft^2	92 µg/ft^2	95% Chebyshev (Mean, STD)	108.3 µg/ft^2
	Wipe - Floors	24	1/24	50 µg/ft^2	350 µg/ft^2	102.1 µg/ft^2	95% Chebyshev (Mean, STD)	152.0 µg/ft^2
	Wipe - Walls	31	1/31	50 µg/ft^2	785 µg/ft^2	115.6 µg/ft^2	95% Chebyshev (Mean, STD)	213.8 µg/ft^2
Cristobalite	Bulk Dust	9	0/9	0.04 %	4.95 %	1.45 %	97.5% Chebyshev (Mean, STD)	4.69 %
	Air	32	0/32	8 µg/m^3	11 µg/m^3	8.78 µg/m^3	95% Chebyshev (Mean, STD)	9.4 µg/m^3
	Wipe - All	80	0/80	50 µg/ft^2	100 µg/ft^2	91.9 µg/ft^2	95% Chebyshev (Mean, STD)	100.9 µg/ft^2
	Wipe - Counter	25	0/25	50 µg/ft^2	100 µg/ft^2	92 0 µg/ft^2	95% Chebyshev (Mean, STD)	108.3 µg/ft^2
	Wipe - Floors	24	0/24	50 µg/ft^2	100 µg/ft^2	91.7 µg/ft^2	95% Chebyshev (Mean, STD)	108.6 µg/ft^2
	Wipe - Walls	31	0/31	50 µg/ft^2	100 µg/ft^2	91.9 µg/ft^2	95% Chebyshev (Mean, STD)	106.6 µg/ft^2
Gypsum	Bulk Dust	9	1/9	0.02 %	2.38 %	0.76 %	97.5% Chebyshev (Mean, STD)	2.33 %

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-5

Residential Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Anaylte	Matrix			Minimum*	Maximum			
	Air	32	0/32	4 µg/m^3	5 5 µg/m^3	4.23 µg/m^3	95% Chebyshev (Mean, STD)	4.59 µg/m^3
	Wipe - All	80	0/80	25 µg/ft^2	50 µg/ft^2	45.9 µg/ft^2	95% Chebyshev (Mean, STD)	50.5 µg/ft^2
	Wipe - Counter	25	0/25	25 µg/ft^2	50 µg/ft^2	46.0 µg/ft^2	95% Chebyshev (Mean, STD)	54.2 µg/ft^2
	Wipe - Floors	24	0/24	25 µg/ft^2	50 µg/ft^2	45.8 µg/ft^2	95% Chebyshev (Mean, STD)	54.3 µg/ft^2
	Wipe - Walls	31	0/31	25 µg/ft^2	50 µg/ft^2	46.0 µg/ft^2	95% Chebyshev (Mean, STD)	53.3 µg/ft^2
Portlandite	Bulk Dust	9	0/9	0 04 %	4.95 %	1.45 %	97.5% Chebyshev (Mean, STD)	4.69 %
	Air	32	0/32	8 µg/m^3	11 µg/m^3	8.78 µg/m^3	95% Chebyshev (Mean, STD)	9.4 µg/m^3
	Wipe - All	80	0/80	50 µg/ft^2	100 µg/ft^2	91.9 µg/ft^2	95% Chebyshev (Mean, STD)	100.9 µg/ft^2
	Wipe - Counter	25	0/25	50 µg/ft^2	100 µg/ft^2	92.0 µg/ft^2	95% Chebyshev (Mean, STD)	108.3 µg/ft^2
	Wipe - Floors	24	0/24	50 µg/ft^2	100 µg/ft^2	91.7 µg/ft^2	95% Chebyshev (Mean, STD)	108.6 µg/ft^2

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-5

Residential Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Anaylte	Matrix			Minimum*	Maximum			
	Wipe - Walls	31	0/31	50 µg/ft^2	100 µg/ft^2	91.9 µg/ft^2	95% Chebyshev (Mean, STD)	106.6 µg/ft^2
Tridymite	Bulk Dust	9	0/9	0.04 %	4.95 %	1.45 %	97.5% Chebyshev (Mean, STD)	4.69 %
	Air	32	0/32	8 µg/m^3	11 µg/m^3	8.78 µg/m^3	95% Chebyshev (Mean, STD)	9.4 µg/m^3
	Wipe - All	80	0/80	50 µg/ft^2	100 µg/ft^2	91.9 µg/ft^2	95% Chebyshev (Mean, STD)	100.9 µg/ft^2
	Wipe - Counter	25	0/25	50 µg/ft^2	100 µg/ft^2	92.0 µg/ft^2	95% Chebyshev (Mean, STD)	108.3 µg/ft^2
	Wipe - Floors	24	0/24	50 µg/ft^2	100 µg/ft^2	91.7 µg/ft^2	95% Chebyshev (Mean, STD)	108.6 µg/ft^2
	Wipe - Walls	31	0/31	50 µg/ft^2	100 µg/ft^2	91.9 µg/ft^2	95% Chebyshev (Mean, STD)	106.6 µg/ft^2
Total Dust	Wipe	26	26/26	0.366 mg/ft^2	18.1 mg/ft^2	10.7 mg/ft^2	95% Chebyshev (Mean, STD)	15.0 mg/ft^2

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-5

Table 6-6. Summary of the analytical results for the mineral compounds and total dust from the background study. The table presents the sample size, frequency of detection, minimum and maximum detected concentrations, arithmetic mean, the statistic used, and the upper confidence limit (UCL) for each compound and matrix sampled. The values in this table were calculated using only the data sets from the common areas for each analyte.

Common Area Data Set		**n**	**Freq. Of Detection**	**Range**		**Arithmetic Mean**	**Statistic**	**UCL**
Anaylte	**Matrix**			**Minimum***	**Maximum**			
Alpha-quartz	Bulk Dust	0	--------	--------	--------	--------	--------	--------
	Air	14	4/14	2 μg/m³	9 μg/m³	3.14 μg/m³	95% Chebyshev (Mean, STD)	5.64 μg/m³
	Wipe - All	33	20/33	12.5 μg/ft²	1880 μg/ft²	149.9 μg/ft²	97.5% Chebyshev (Mean, STD)	508.5 μg/ft²
	Wipe - Counter	7	3/7	12.5 μg/ft²	220 μg/ft²	65.4 μg/ft²	95% H-UCL	288.5 μg/ft²
	Wipe - Floors	8	7/8	25 μg/ft²	1880 μg/ft²	357.5 μg/ft²	97.5% Chebyshev (Mean, STD)	1769.4 μg/ft²
	Wipe - Walls	18	10/18	25 μg/ft²	270 μg/ft²	90.6 μg/ft²	95% Chebyshev (Mean, STD)	180.1 μg/ft²
Calcite	Bulk Dust	0	--------	--------	--------	--------	--------	--------
	Air	14	0/14	8 μg/m³	10 μg/m³	8.86 μg/m³	95% Chebyshev (Mean, STD)	9.75 μg/m³
	Wipe - All	34	1/34	50 μg/ft²	260 μg/ft²	98.8 μg/ft²	95% Chebyshev (Mean, STD)	123.4 μg/ft²
	Wipe - Counter	7	0/7	50 μg/ft²	100 μg/ft²	92 9 μg/ft²	95% Chebyshev (Mean, STD)	124.0 μg/ft²
	Wipe - Floors	9	1/9	50 μg/ft²	260 μg/ft²	112.2 μg/ft²	95% Chebyshev (Mean, STD)	196.2 μg/ft²
	Wipe - Walls	18	0/18	50 μg/ft²	100 μg/ft²	94.4 μg/ft²	95% Chebyshev (Mean, STD)	111.1 μg/ft²
Cristobalite	Bulk Dust	0	--------	--------	--------	--------	--------	--------
	Air	14	0/14	8 μg/m³	10 μg/m³	8.86 μg/m³	95% Chebyshev (Mean, STD)	9.75 μg/m³

* Minimum detected value includes values that may be ½ of the detection limit

Common Area Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Anaylte	Matrix			Minimum*	Maximum			
	Wipe - All	34	1/34	50 µg/ft²	260 µg/ft²	98.8 µg/ft²	95% Chebyshev (Mean, STD)	123.4 µg/ft²
	Wipe - Counter	7	0/7	50 µg/ft²	100 µg/ft²	92.9 µg/ft²	95% Chebyshev (Mean, STD)	124.0 µg/ft²
	Wipe - Floors	9	1/9	50 µg/ft²	260 µg/ft²	112.2 µg/ft²	95% Chebyshev (Mean, STD)	196.2 µg/ft²
	Wipe - Walls	18	0/18	50 µg/ft²	100 µg/ft²	94.4 µg/ft²	95% Chebyshev (Mean, STD)	111.1 µg/ft²
Gypsum	Bulk Dust	0	--------	--------	--------	--------	--------	--------
	Air	14	0/14	4 µg/m³	5 µg/m³	4.29 µg/m³	95% Chebyshev (Mean, STD)	4.83 µg/m³
	Wipe - All	34	0/34	25 µg/ft²	50 µg/ft²	47.1 µg/ft²	95% Chebyshev (Mean, STD)	53.2 µg/ft²
	Wipe - Counter	7	0/7	25 µg/ft²	50 µg/ft²	46.4 µg/ft²	95% Chebyshev (Mean, STD)	62.0 µg/ft²
	Wipe - Floors	9	0/9	25 µg/ft²	50 µg/ft²	47.2 µg/ft²	95% Chebyshev (Mean, STD)	59.3 µg/ft²
	Wipe - Walls	18	0/18	25 µg/ft²	50 µg/ft²	47.2 µg/ft²	95% Chebyshev (Mean, STD)	55.5 µg/ft²
Portlandite	Bulk Dust	0	--------	--------	--------	--------	--------	--------
	Air	14	0/14	8 µg/m³	10 µg/m³	8.86 µg/m³	95% Chebyshev (Mean, STD)	9.75 µg/m³
	Wipe - All	34	0/34	50 µg/ft²	100 µg/ft²	94.1 µg/ft²	95% Chebyshev (Mean, STD)	106.3 µg/ft²
	Wipe - Counter	7	0/7	50 µg/ft²	100 µg/ft²	92.9 µg/ft²	95% Chebyshev (Mean, STD)	124.0 µg/ft²
	Wipe - Floors	9	0/9	50 µg/ft²	100 µg/ft²	94.4 µg/ft²	95% Chebyshev (Mean, STD)	118.7 µg/ft²
	Wipe - Walls	18	0/18	50 µg/ft²	100 µg/ft²	94.4 µg/ft²	95% Chebyshev (Mean, STD)	111.1 µg/ft²
Tridymite	Bulk Dust	0	--------	--------	--------	--------	--------	--------

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-6

Common Area Data Set		n	Freq. Of Detection	Range		Arithmetic Mean	Statistic	UCL
Anaylte	Matrix			Minimum*	Maximum			
	Air	14	0/14	8 $\mu g/m^3$	10 $\mu g/m^3$	8.86 $\mu g/m^3$	95% Chebyshev (Mean, STD)	9.75 $\mu g/m^3$
	Wipe - All	34	0/34	50 $\mu g/ft^2$	100 $\mu g/ft^2$	94.1 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	106.3 $\mu g/ft^2$
	Wipe - Counter	7	0/7	50 $\mu g/ft^2$	100 $\mu g/ft^2$	92.9 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	124.0 $\mu g/ft^2$
	Wipe - Floors	9	0/9	50 $\mu g/ft^2$	100 $\mu g/ft^2$	94.4 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	118.7 $\mu g/ft^2$
	Wipe - Walls	18	0/18	50 $\mu g/ft^2$	100 $\mu g/ft^2$	94.4 $\mu g/ft^2$	95% Chebyshev (Mean, STD)	111.1 $\mu g/ft^2$
Total Dust	Wipe	9	9/9	5.3 mg/ft^2	17.5 mg/ft^2	10.7 mg/ft^2	95% Chebyshev (Mean, STD)	17.2 mg/ft^2

* Minimum detected value includes values that may be ½ of the detection limit

Table 6-6

Table 7-1. Summary of U.S. Residential Building Average Indoor Airborne Asbestos Concentrations for Asbestos Fibers ≥ 5 μm Long by Direct Transmission Electron Microscopy

Site Description	Number of Samples	Asbestos Fibers ≥ 5 μm Long (f/cc)		Reference
		Range	Mean	
15 San Francisco residences (houses) with ACM	30	ND	ND	CPSC 1987
15 Cleveland residences (houses) with ACM	30	ND - 0.002	0.00023	CPSC 1987
15 Philadelphia residences (houses) with ACM	29	ND - 0 001	0.00007	CPSC 1987
10 residential building	10	-	0.00000	Lee et al. 1992
1 San Francisco area residential building sampled following the 1989 Loma Prieta earthquake	2	-	0.00213	Van Orden et al. 1995

Source: Adapted from HEI (1991), ATSDR (2001), Van Orden et al. (1995)

ACM = asbestos-containing material; ND = non-detect

Table 7-2. Summary of Settled Asbestos Surface Dust Loadings Determined Through Microvacuum Sampling and Indirect Analysis by Transmission Electron Microscopy

Building Category	Number of Buildings	Number of Samples	Surface Loading of Asbestos Structures (s/cm^2)	
			Range	Geometric Mean
Outside buildings in a large city	5	79	<400 to 140,000	5100
Inside buildings with no surfacing ACM	6	28	<240 to 210,000	1000
Areas of buildings with acoustical plaster	12	34	<3500 to 74 million	160,000

Source: Ewing (2000).

ACM = asbestos-containing material

Table 7-3. Household Dust Lead Measurements from Wipe Sampling in an Old, Urban Community

Sample Collection Site	Number of Samples (see note below)	Median	Range	EPA Standard	Percentage above standard
		(μg/ft²)	(μg/ft²)	(μg/ft²)	
Non-carpeted floors	124	12	3 - 369	40	23
Carpeted floors	65	5	3 - 78	40	5

Source. Gallicchio et al. (2002)

Note: Each reported sample was a composite of wipe samples taken from three different rooms.

Table 7-4. Estimated Distribution of Lead Loadings (ug/ft²) In U.S. Housing

Uncarpeted Floors, By Census Region and Building Age Category (source: HUD 2001)

Region	Age of Housing	n	mean	std	skew	cv	var	stderr	max	P99	P95	P90	Q3	median	Q1	P5	min	detection rate	% nondetects
Northeast	1978 - 1998	92	1.6	19.4	3.5	11.8	3.76e+02	0.2	11.0	11.0	5.5	3.0	1.6	1.0	0.8	0.8	0.8	21 / 92	77%
Northeast	1960 - 1977	79	5.1	193.1	7.5	38.2	3.73e+04	2.0	129.6	129.6	8.0	6.0	3.0	1.0	0.8	0.8	0.8	30 / 79	62%
Northeast	1946 - 1959	68	3.1	40.8	2.4	13.1	1.66e+03	0.5	17.0	17.0	15.0	9.0	3.0	1.2	0.8	0.8	0.8	30 / 68	56%
Northeast	1940 - 1945	38	5.3	80.9	4.5	15.2	6.55e+03	1.3	75.0	75.0	13.0	10.0	7.0	4.1	1.0	0.8	0.8	23 / 38	39%
Northeast	<= 1939	155	24.0	1765.8	12.2	73.7	3.12e+06	12.9	1845.0	128.0	56.7	31.0	9.0	4.0	1.4	0.8	0.8	111 / 155	28%
Midwest	1978 - 1998	87	1.5	18.8	4.6	12.5	3.52e+02	0.2	18.0	9.6	4.0	3.0	1.6	0.8	0.8	0.8	0.8	16 / 87	82%
Midwest	1960 - 1977	133	2.8	74.0	5.5	26.2	5.47e+03	0.6	72.0	22.0	12.1	5.0	2.0	1.0	0.8	0.8	0.8	45 / 133	66%
Midwest	1946 - 1959	85	8.4	210.9	4.3	25.1	4.45e+04	2.0	105.0	91.0	52.0	18.0	5.0	2.0	1.0	0.8	0.8	47 / 85	45%
Midwest	1940 - 1945	25	15.1	269.8	2.6	17.8	7.28e+04	4.3	92.0	92.0	71.0	33.2	20.8	10.2	1.0	0.8	0.8	15 / 25	40%
Midwest	<= 1939	124	56.4	4087.2	10.9	72.5	1.67e+07	37.8	4830.0	386.0	107.0	47.0	15.0	5.0	0.8	0.8	0.8	92 / 124	26%
South	1978 - 1998	196	2.0	200.0	9.9	99.4	4.00e+04	1.2	556.0	9.0	5.0	3.0	1.6	0.8	0.8	0.8	0.8	??	71%
South	1960 - 1977	223	1.7	25.8	5.4	15.3	6.65e+02	0.2	28.0	12.0	6.0	3.0	1.6	1.0	0.8	0.8	0.8	??	??
South	1946 - 1959	125	7.0	378.8	10.8	54.5	1.44e+05	3.2	315.0	315.0	14.0	6.0	3.0	1.2	0.8	0.8	0.8	??	??
South	1940 - 1945	43	4.8	88.1	3.8	18.3	7.77e+03	1.2	56.0	56.0	17.0	9.0	5.0	2.5	1.2	0.8	0.8	??	??
South	<= 1939	80	17.2	479.3	3.9	27.8	2.30e+05	5.1	404.3	233.0	60.0	32.1	12.0	4.0	1.8	0.8	0.8	??	??
West	1978 - 1998	115	2.7	233.6	10.7	85.5	5.46e+04	2.0	276.0	10.0	3.0	1.6	1.0	0.8	0.8	0.8	0.8	??	??
West	1960 - 1977	195	1.6	11.5	2.7	7.2	1.32e+02	0.1	11.0	6.0	4.0	3.0	2.0	1.0	0.8	0.8	0.8	??	??
West	1946 - 1959	77	3.9	62.3	4.0	16.0	3.88e+03	0.8	47.0	39.0	15.0	9.0	3.0	1.5	0.9	0.8	0.8	??	??
West	1940 - 1945	21	4.0	34.1	0.9	8.5	1.16e+03	0.7	9.0	9.0	9.0	9.0	7.0	4.0	1.5	0.8	0.8	??	??
West	<= 1939	39	5.0	83.9	3.1	16.7	7.05e+03	1.2	41.0	41.0	27.0	11.0	4.0	2.1	1.1	0.8	0.8	??	??

Table 7-5. Background Soil Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs)

Compound	Concentrations (µg/kg)		
	Rural soil	Agricultural Soil	Urban Soil
Acenaphthene	1.7	6	
Acenaphthylene		5	
Anthracene		11–13	
Benzo(a)anthracene	5–20	56–110	169–59,000
Benzo(a)pyrene	2–1,300	4.6–900	165–220
Benzo(b)fluoranthene	20–30	58–220	15,000–62,000
Benzo(e)pyrene		53–130	60–14,000
Benzo(g,h,i)perylene	10–70	66	900–47,000
Benzo(k)fluoranthene	10–110	58–250	300–26,000
Chrysene	38.3	78–120	251–640
Fluoranthene	0.3–40	120–210	200–166,000
Fluorene		9.7	
Ideno(1,2,3-c,d)pyrene	10–15	63–100	8,000–61,000
Phenanthrene	30.0	48–140	
Pyrene	1–19.7	99–150	145–147,000

[a]Derived from:

IARC 1973
White and Vanderslice 1980
Windsor and Hites 1979
Edwards 1983
Butler et al. 1984
Vogt et al. 1987
Jones et al. 1987

Source. ATSDR (1995)

Table 8-3. An evaluation was conducted to determine how the estimated UCLs were effected by assigning 1/2 of the detection limit for samples that were below the detection limit (DL) In general, the variation between the different methods (i e., ND=0, ND=1 2, and ND=DL) are directly related to the frequency of detection. As illustrated below, the lower the frequency of detection, the greater the variability, with values ranging from 100% less to 100% greater for data sets that contained all values below the detection limit The use of 1/2 of the detection limit results in a mid-point estimate.

Analyte	Surface	Freq. Of Detection (%)	ND=0 UCL	ND=1/2 UCL	ND=DL UCL	Percent Difference ND=0/ND=1/2	Percent Difference ND=DL/ND=1/2
Lead	Bulk Dust	100%	186	186	186	0%	0%
Total Dust	Hard Surface	100%	14 4	14 4	14 4	0%	0%
Lead	Hard Surface	49%	1 69	1 78	1 88	-5%	5%
Asbestos	PCM - Air	42%	0 0022	0 0023	0 0025	-6%	7%
Alpha-quartz	Hard Surface	38%	68 3	79 6	91 8	-14%	15%
Asbestos	Hard Surface	13%	5,462	6,192	6,965	-12%	12%
MMVF	Hard Surface	10%	29	52	76	-44%	46%
MMVF	Air	8%	0 034	0 060	0 088	-44%	45%
Lead	Porous Surface	8%	1 00	1 98	2 95	-49%	49%
Asbestos	PCMe	5%	0 00007	0 00024	0 00044	-72%	80%
Asbestos	TEM AHERA - Air	4%	0 00007	0 00024	0 00043	-72%	80%
Calcite	Hard Surface	3%	60 8	132 3	232 3	-54%	76%
Lead	Air	2%	0 0068	0 0304	0 0549	-78%	81%
Cristobalite	Hard Surface	1%	12 2	103 7	200 5	-88%	93%
Calcite	Air	0%	0	9.3	18.6	-100%	100%
Cristobalite	Air	0%	0	9.3	18.6	-100%	100%
Gypsum	Air	0%	0	9.3	18.6	-100%	100%
Gypsum	Hard Surface	0%	0	49.9	99.8	-100%	100%
Portlandite	Air	0%	0	9.3	18.6	-100%	100%
Portlandite	Bulk Dust	0%	0	4.69	9.37	-100%	100%
Portlandite	Hard Surface	0%	0	99.8	199.7	-100%	100%
Tridymite	Air	0%	0	9.3	18.6	-100%	100%
Tridymite	Bulk Dust	0%	0	4 69	9.37	-100%	100%
Tridymite	Hard Surface	0%	0	99.8	199.7	-100%	100%

These data sets were not included in the above table because the frequency of detection or the variability in the three values that were calculated were altered by additional factors, thus they are reported separately

† These values are also influenced by a change in distribution from either non-parametric to lognormal or lognormal to non-parametric due to altering the values between ND=0, ND=1/2, and ND=DL This required different statistical methods to be used which resulted in the comparison of the three values not being similar to comparing values that were calculated using the same statistic

‡These values are also influenced by the way that the frequency of detection is calculated, as there are 17 different dioxin congeners This results in the comparison with the other data being dissimilar as they are based on the frequency of detection of a single compound For example, one sample may have detected one congener, while a second sample detected 15 congeners Each sample would be considered to be above the detection limit, however the values used to estimate the UCL would be altered for 16 congeners in one sample but only for 2 congeners in the second sample, thus creating greater variability from the other data sets

* These values are also influenced by a change in variability within the data set due to altering the values between ND=0, ND=1/2, and ND=DL This changed the standard deviation of the data set which required a different confidence interval to be used to estimate the UCL The comparison of values that use different confidence intervals resulted in the comparison not being similar to the other data sets

Analyte	Surface	Freq. Of Detection (%)	ND=0 UCL	ND=1/2 UCL	ND=DL UCL	Percent Difference ND=0/ND=1/2	Percent Difference ND=DL/ND=1/2
Alpha-quartz	Bulk Dust†	89%	3 88	3 66	4 97	6%	36%
Dioxin	Hard Surface‡	77%	0 087	0 693	1 330	-87%	92%
Alpha-quartz	Air*	25%	45 5	61 9	48 0	-26%	-22%
Calcite	Bulk Dust†	11%	0 61	3 41	7 05	-82%	107%
Gypsum	Bulk Dust†	11%	1 42	2 33	4 71	-39%	102%
Cristobalite	Bulk Dust†	0%	0	4.69	10 70	-100%	128%

ATTACHMENTS

A

ATTACHMENT A

World Trade Center Indoor Air Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks

World Trade Center Indoor Air Assessment: Selecting Contaminants of Potential Concern and Setting Health-Based Benchmarks

Prepared by the Contaminants of Potential Concern (COPC) Committee of the World Trade Center Indoor Air Taskforce Working Group

Contributors:

U.S Environmental Protection Agency
Mark Maddaloni
Peter Grevatt
Terry Smith
Dore LaPosta
Charles Nace
John Schaum
Dana Tulis

New York City Department of Health
Nancy Jeffery
Ken Carlino
Jeanine Prudhomme
Chris D'Andrea
Vince Colucci
Caroline Bragdon
James Miller

Agency for Toxic Substances and Disease Registry
Sven Rodenbeck
Danielle Devoney

New York State Department of Health
Robert Chinery

Occupational Safety and Health Administration
David Ippolito
Dan Crane

Peer Review Draft (September, 2002)

Table of Contents

Tables

World Trade Center Indoor Air Assessment:
Selecting Contaminants of Potential Concern
And Setting Health-Based Benchmarks

Introduction

Since September 11, 2001, the outdoor environment around the World Trade Center (WTC) site and nearby areas has been extensively monitored by a group of federal, state, and local agencies[1]. The agencies have taken samples of the air, dust, water, river sediments and drinking water and analyzed them for the presence of pollutants that might pose a health risk to response workers at the WTC site, office workers, and local residents. While some people may have experienced acute irritant and respiratory effects from the collapse of the towers and associated fires, extended monitoring of the ambient air at and beyond the perimeter of the WTC site over the past year indicates that contaminant concentrations pose a low risk of long-term health effects. During this same time period, limited investigation of the indoor environment in residential dwellings has occurred [NYCDOH, 2002; Chatfield & Kominsky, 2001] As the cleanup of the WTC site is coming to an end, governmental health and environmental agencies are directing resources to evaluate the indoor environment for the presence of pollutants that might pose long-term health risks to local residents. Selecting Contaminants of Potential Concern (COPCs) and setting health-based benchmarks will assist the Pilot Cleaning Effectiveness Initiative[2] and inform the selection of contaminants in the Background Study[3].

Selecting the Contaminants of Potential Concern (COPCs)

The assessment of the indoor environment began with a review of historical information on hazardous substances that have been associated with building fires and collapses [Wallace, 1990]. Many compounds, including combustion by-products such as dioxins and polycyclic aromatic hydrocarbons (PAHs) were identified for further investigation, along with building materials such as asbestos and fibrous glass. In addition, ambient air, indoor air, and indoor/outdoor bulk dust monitoring data were reviewed. Data sources included EPA's ambient air and bulk dust/debris monitoring program (www.epa gov/wtc), OSHA's air/dust monitoring

---

[1] Agencies include the U S. Environmental Protection Agency (EPA), Agency for Toxics and Disease Registry (ATSDR), New York State Department of Health (NYSDOH), New York City Department of Health (NYCDOH), Occupational Safety and Health Administration (OSHA), New York State Department of Environmental Conservation (NYSDEC) and New York City Department of Environmental Protection (NYCDEP)

[2]EPA is conducting a pilot program in an uncleaned/unoccupied building at 110 Liberty Street to determine the effectiveness of various cleaning methods for removing asbestos and other contaminants of potential concern from residential dwellings

[3]Most if not all of the pollutants associated with the collapse of the World Trade Center were present in New York City's environment prior to September 11 To establish a baseline for the presence of these contaminants in affected residences, EPA will collect and analyze samples to look for some of these pollutants in apartments in parts of Manhattan that were not impacted The Agency will use the data to determine pre-existing or "background" levels of these pollutants in interior spaces in New York City

data and the NYCDOH/ATSDR indoor air pilot program [NYCDOH, 2002]. A concerted effort also was made to identify and review additional sources of WTC-related data from other governmental agencies (e g , U.S. Geological Survey, NYC Board of Education), academic institutions, environmental organizations, and the private sector.

A semi-quantitative screening process was performed on the collected sampling data. Based on frequency-of-detection, concentration and inherent toxicity, contaminants that exceeded health-based screening levels for the ambient air (see Appendix B) were identified. Dioxin and PAHs were added to the COPC list by this process. In addition, building constituents with carcinogenic (asbestos) or irritant effects (fibrous glass, crystalline silica) that were consistently and significantly found in bulk debris and indoor dust samples were identified as COPCs [NYCDOH, 2002] . Finally, lead (Pb) was included based on a comparison of sampling data with existing regulatory standards. Collectively, the resulting group of contaminants are called "contaminants of potential concern" or COPCs in this report

The list of COPCs is shown in the column at the left, below. Included for each COPC is a data summary that supports its inclusion on the list For completeness, an additional list is included on the right containing substances that, for various reasons, have created concern, but on closer inspection, were either rarely detected in the ambient air and/or settled dust sampling around the WTC, or routinely found at concentrations below the health-based screening criteria presented in Appendix B.

COPCs	Other Substances
Lead	Benzene
PAHs	PCBs
Dioxin	Chromium
Asbestos	Cadmium
Fibrous Glass	Manganese
Crystalline Silica	Mercury
	Particulate Matter
	Refractory Ceramic Fibers
	Mold

Lead and Combustion By-Products (PAHs, Dioxin)

Lead. EPA's ambient air monitoring data detected lead in concentrations that exceeded 1.5 ug/m^3 on five occasions from September 18-27, 2001. It should be noted that the National Ambient Air Quality Standard (NAAQS) for lead is 1.5 ug/m^3, but is based on a three-month average. Since the ambient monitoring program began, no three-month average of the ambient air data for lead exceeded the NAAQS of 1.5 ug/m^3. However, lead was more commonly found at concentrations that exceeded 0.1 ug/m^3, the default value employed in EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children [EPA, 1994]. This value represents the upper-bound of average of ambient airborne lead concentrations in urban environments. Additional support for including lead as a COPC was provided by a report that characterized the dust that settled over lower Manhattan after the WTC collapse [Lioy, 2002]. The lead concentration in settled dust ranged from 101 - 625 parts per million (ppm). By itself, this range does not represent extraordinarily high concentrations, but in combination with the mass of material released from the collapse of the towers, it represents a potentially significant increase in the mass of lead deposited in lower Manhattan. Therefore, lead is included as a COPC

PAHs. Limited ambient air sampling was conducted for PAHs during the period of time (September through December, 2001) when combustion processes were occurring at the site. However, concentrations in bulk dust [EPA, 2002a and Lioy, 2002] exceeded the removal guidelines for soil in EPA's Hazard Evaluation Handbook [EPA, 1997] of 9 ppm based on benzo(a)pyrene equivalents. This value is risk-based, equating to an excess lifetime cancer risk of 1×10^{-4} over a 30-year exposure duration for residential settings. Therefore, PAHs are included as a COPC.

Dioxin. Ambient air samples exceeded EPA's screening criteria (see Appendix B) at various sampling stations during September and October, 2001. Data trend analysis for dioxin in ambient air [EPA, 2002a] showed that concentrations significantly exceeded the risk-based screening level of 0.001 - 0.005 ng/m^3. This range was based on an excess lifetime cancer risk of 1×10^{-4} over a 30 year exposure duration for residential settings, using both the existing cancer Slope Factor [Integrated Risk Information System (IRIS), 2002] and proposed cancer Slope Factor in EPA's draft dioxin reassessment [EPA, 2001]. Therefore, dioxin (and related congeners) is included as a COPC.

Building Materials (Asbestos, Fibrous Glass, Crystalline Silica)

The evaluation of building materials for inclusion as COPCs required a different approach than that used for the combustion by-products. Those compounds (PAHs, dioxin) benefit from consensus toxicity criteria (i.e., IRIS-established cancer Slope Factors) that allow for a quantitative screening paradigm. With the exception of asbestos, the building materials evaluated (including fibrous glass, crystalline silica, mica, portlandite, calcite and gypsum) do not have IRIS inhalation toxicity criteria from which to perform quantitative risk assessments. Complicating this matter is the knowledge that many of these substances were deposited in a large cloud from the collapse of the towers. Thus, the settled dust may serve as a reservoir for re-suspension and eventual inhalation exposure. In addition, materials such as fibrous glass can also cause contact irritation when exposed directly to the skin.

The potential for exposure to building materials in the indoor environment was assessed by reviewing sampling data on the constituent composition of the indoor/outdoor bulk dust and indoor/ambient air [EPA, 2002c; USGS, 2001; NYCDOH, 2002, Chatfield & Kominsky, 2001].

Toxicity criteria for building materials (with the exception of asbestos) were obtained from occupational sources, such as the Occupational Safety and Health Administration's permissible exposure limits (OSHA PELs), and the American Conference of Governmental Industrial Hygienists threshold limit values (ACGIH TLVs). The evaluation of exposure potential coupled with toxicity information identified three COPCs (asbestos, fibrous glass and crystalline silica).

Asbestos. In the days immediately following the disaster, EPA analyzed the settled bulk dust/debris for asbestos content. More than one third of the approximately 150 samples registered an asbestos concentration greater than 1% [EPA 2002c]. Since that time, EPA has taken the position that WTC-related dust should be considered potentially asbestos-contaminated and handled accordingly. Additionally, indoor settled dust samples collected from residential buildings in November and December 2001 indicated that 18% of the indoor locations sampled contained measurable levels of asbestos [NYCDOH, 2002]. Therefore, asbestos is included as a COPC.

Fibrous Glass. Analysis of WTC bulk dust/debris has consistently identified fibrous glass to be a major constituent of the material [Lioy 2002, USGS 2001]. In addition, an NYCDOH/ATSDR study [NYCDOH, 2002] found fibrous glass in the interior settled dust in 41% of the locations sampled at concentrations up to 35%. Air samples collected in areas with fibrous glass in settled dust indicate no fiber levels of immediate concern Although fiber counts were found in four areas with slightly greater than background (0.004-0.006 f/cc), subsequent re-analysis indicated actual fibrous glass concentrations from these areas as 0.00004 to 0.00026 f/cc. Air samples from remaining areas showed a maximum 0.003 f/cc total fiber count by PCM. These wools may be skin, eye, and respiratory tract irritants. Although there are no standards to evaluate the settled dust content, the presence of fibrous glass in settled dust does indicate a potential for exposure Therefore, fibrous glass is included as a COPC.

Crystalline Silica. Settled dust and air samples taken in indoor and outdoor areas of residential buildings in November and December of 2001 indicate the presence of alpha-quartz. Other forms of crystalline silica were not found. This is consistent with outdoor dust and debris samples collected by the USGS [USGS, 2001] and subjected to mineral analysis Quartz was found in approximately 49% of the settled dust samples from indoor areas of residential buildings and all of the associated outdoor areas sampled. Levels of quartz ranged as high as an estimated 31.4% of the dust by weight in a residence. Since quartz is a common material in sand, finding this mineral in a city where there is a great deal of concrete is not unusual. However, quartz in dust from a comparison area unaffected by the WTC collapse ranged from non-detect only up to an estimated 2.2% in the residence [NYCDOH, 2002]. Seventeen residential areas and eleven common areas had quartz levels greater than the associated comparison area. Therefore, quartz was deemed to be elevated in some indoor areas of lower Manhattan relative to the comparison area Additionally, quartz was found in 13% of the respirable fraction air samples taken in these areas, ranging from an estimated 4-19 ug/m3, demonstrating a potential for exposure. Although below occupational standards, this estimated concentration is above the effective NAAQS standard for the silica fraction of respirable particulate matter. Therefore crystalline silica, measured as alpha-quartz, is included as a COPC.

In addition to crystalline silica, calcite, portlandite and gypsum were the most abundant minerals detected in settled dust samples from residential areas in lower Manhattan following the WTC collapse. Mica was detected with much less frequency, generally at less than 0.1% of the dust. Halite (salt) was also detected at trace levels. Calcite, portlandite, and gypsum are typical components of concrete and gypsum based wallboard products, which were present in the WTC buildings. While high concentrations of these minerals in airborne dust constitute a short-term health concern in the form of eye, nose and throat irritation, persisting adverse heath effects would not be anticipated, unless these minerals remained suspended in high concentrations. Indoor and street-level outdoor air sampling done in November and December of 2001 show that the levels of these chemicals, over a time-weighted sample, were below levels associated with irritant effects (See Table 1). Although there are methodological difficulties in quantifying these materials by X-ray Diffraction (XRD) techniques, a semi-quantitative screening of the results showed that the air levels were orders of magnitude below occupational standards for irritant effects. However, since the presence of minerals in settled dust indicates there is potential for the materials to be resuspended, these minerals should be evaluated qualitatively. Therefore, although no screening levels are developed for these minerals as COPCs, the Pilot Cleaning Effectiveness Initiative mentioned in the Introduction will report qualitatively on the presence of gypsum, calcite and portlandite, while the quantitative analyses for crystalline silica (a COPC discussed above) are being performed by XRD (following NIOSH Method 7500).

Table 1. Index of NIOSH and OSHA exposure limits and estimated maximum values in Lower Manhattan.

Mineral	NIOSH REL (ug/m^3)	OSHA PEL (ug/m^3)	*Maximum Estimated Value (J) in Lower Manhattan (ug/m^3)
Gypsum	10,000 ug/m^3 (total) 5,000 (ug/m^3 resp)	15,000 ug/m^3 (total) 5,000 (resp)	14J (PM100) 15J (PM4)
Portlandite	5,000 ug/m^3	15,000 ug/m^3 (total) 5,000 ug/m^3 (resp)	95J (PM100) 84J (PM4)
Calcite	10,000 ug/m^3 (total) 5,000 ug/m^3 (resp)	15,000 ug/m^3 (total) 5,000 ug/m^3 (resp)	14J (PM100) 10J (PM 4)

NIOSH = National Institute of Occupational Safety and Health, Centers for Disease Control and Prevention
REL = recommended exposure level/limit
OSHA = Occupational Safety and Health Administration
PEL = permissible exposure limit.
resp = respirable
* [NYCDOH, 2002]

Other Substances that Were not Selected to be COPCs

The following summary is provided for substances that were investigated, but not included on the COPC list. A full discussion of the reasons is provided in Appendix A.

Chemical	Reason
Benzene	Benzene is very volatile and dissipates into ambient air quickly. Grab samples that recorded high (above the OSHA PEL of 1 ppm) concentrations on the debris pile consistently dropped to below detection limits (20 ppb) at the site perimeter.
PCBs	In over 500 ambient air samples taken around the WTC work zone, none exceeded EPA's screening level of concern for ambient air (see Appendix B).
Chromium	All measurements (over 300 samples) of chromium in ambient air around the WTC work zone have been below EPA's screening level of concern for the ambient air (see Appendix B). Measurements in settled dust have been below EPA Removal Action Guidelines [EPA, 1997].
Cadmium	Cadmium was found in only two out of 300 air samples at levels greater than EPA's screening level for ambient air (Appendix B). Measurements in settled dust have been below EPA Removal Action Guidelines [EPA, 1997].
Manganese	Manganese was found in only four of over 300 air samples at levels that were greater than EPA's screening level for ambient air (Appendix B). Measurements in settled dust have been below EPA Removal Action Guidelines [EPA, 1997]
Mercury	Concern regarding mercury has been raised by a report of slightly elevated blood mercury levels in four Port Authority Police Officers at the WTC site (69 were screened). A NYC Department of Design and Construction report [Rottner, 2002] concluded that air and bulk data have not shown elevated Hg levels. The report also noted that routine urine screening of NYC firefighters assigned to the site did not indicate any sign of Hg exposure. A U.S. Geological Survey leachability study [USGS 2001] of indoor and outdoor WTC settled dust samples showed that it is unlikely that harmful levels of mercury could ever be released to the air. In addition, indoor air sampling using a Lumex Analyzer at numerous residential dwellings close to Ground Zero determined mercury vapor concentrations to be well below EPA's Reference Concentration (RfC) of .3 ug/m^3 [Johnson, 2002].
Particulate Matter (PM)	Ambient monitoring in the WTC area has shown that, since late October, levels of PM 10 and PM 2.5 (two commonly measured inhalable PM sizes) have been below EPA's level of concern for the ambient air (see Appendix B), indicating that there is no continuing source of PM entering homes and offices. EPA's Environmental Data Trend Report World Trade Center, 9/11/01 - 4/24/02 [EPA, 2002a] concluded that PM 2.5 and PM 10 appear to have returned to levels of a steady background state.

Chemical	Reason
Refractory Ceramic Fibers (RCF)	Ceramic fiber-containing materials are not expected to be present in the WTC buildings, as they are mainly used in industrial high temperature applications. Limited sampling conducted by NYCDOH, 2002 did not indicate any ceramic fibers in four indoor air samples analyzed by scanning electron microscopy (SEM).
Mold	Mold was not directly associated with the WTC collapse. However, it may have resulted from the combination of water damage and inoperable HVAC systems. Guidelines for identifying and removing mold are provided through a NYCDOH website (see Appendix A).

Setting Benchmarks for the Contaminants of Potential Concern (COPCs)

A tiered approach was used to evaluate the health risks posed by contaminants that might be present in the indoor environment (air and settled dust). For each COPC, three levels were established:

Tier I — Level above which, after elimination of potential indoor sources (combustion by-products, stored chemicals, etc.), aggressive clean-up action should be taken expeditiously along with follow-up sampling to confirm attainment of Tier III level

Tier II — Range where diligent cleaning should continue, after elimination of potential indoor sources (combustion by-products, stored chemicals, etc.), with follow-up sampling to confirm attainment of Tier III level

Tier III — Level below which the risk is negligible or consistent with the New York City background level found in the aforementioned Background Study (see Introduction).

The following hierarchal approach was employed for developing benchmark values: 1)Use of relevant and appropriate environmental standards/regulations; 2) Calculation of risk-based benchmarks using EPA risk assessment guidance; and, 3) Adaptation of occupational standards with additional safety factors. Accordingly, a review of environmental standards/regulations was conducted for each of the six COPCs. As a result of this exercise Tier I screening levels for lead in indoor air and settled dust were set using EPA's National Ambient Air Quality Standard (NAAQS) and the U.S. Housing and Urban Development's (HUD's) standard for floors, respectively. The clearance criteria established in the Asbestos Hazard Emergency Response Act (AHERA, 1986) of 70 structures/mm2 was utilized to evaluate asbestos samples from the ambient air monitoring effort. As detailed in Appendix B, the upper bound estimate for exposure duration to contaminants in the ambient air was one year. However, given the potential for extended exposure in residential dwellings, AHERA was deemed less appropriate to this setting

In cases where appropriate standards did not exist (e.g , asbestos), risk-based criteria were developed using established EPA risk assessment methods: for indoor air, methods described in EPA's "Risk Assessment Guidance for Superfund" [RAGS, 1989] were used; for settled dust, EPA Region III's "Wipe Sample Assessment" guidance was utilized with modifications (see Appendix D). The risk-based criteria reflect the most current toxicity criteria (Cancer Slope Factors and RfDs/RfCs) on EPA's Integrated Risk Information System (IRIS), which is a regularly updated (quarterly), online database that reports chemical toxicity reference values and information on human health effects that may result from exposure to chemicals in the environment

For contaminants that lacked IRIS verified toxicity criteria, occupational standards were employed. Additional safety factors were added to account for higher exposure and greater sensitivity within the general population.

The clearance criteria paradigm described above is pathway and chemical specific. Accordingly, the benchmarks for each COPC do not account for multimedia and multiple chemical exposure.

Individual sampling results that exceed benchmark values should not be interpreted to represent the occurrence of an adverse health effect. Because benchmark levels assume continuous exposure for an extended duration, the average of the measured concentrations is more appropriate for evaluating risk than individual measurements Consequently, isolated individual values above the benchmark level may not necessarily be indicative of a hazard.

Developing Risk-Based Criteria for Indoor Air

For carcinogenic compounds, the benchmarks were set so that a local resident's lifetime risk of developing cancer from exposure to WTC-related contaminants would not exceed a one-in-ten-thousand probability ($1x10^{-4}$) above the resident's background risk without this exposure. The amount of time that residents and office workers were exposed to WTC-related contaminants is unknown. To be conservative, the Tier I screening level was chosen to be protective of a resident who may have been exposed to WTC-related contaminants for one year. The Tier III clearance level was chosen to be protective of a resident who is exposed to WTC-related contaminants for 30 years, which is the upper-bound estimate for residency in one dwelling [EPA, 1989]. Cancer risk from less-than-lifetime inhalation exposure is given as.

$$\text{Risk} = \text{LAC} * \text{UR}$$

where LAC is the air concentration averaged over a lifetime, calculated as: AC * [EF*ED/LT], where AC is the average air concentration during the period of exposure ($\mu g/m^3$), EF is the exposure frequency (days/year), ED is the exposure duration (years), LT is lifetime (days), and UR is the unit risk factor, expressed in units of 1/concentration.

The following table lists the input parameters and numerical values (along with a brief explanation) used in this procedure. (See Appendix D for equations and a more detailed discussion).

Table 2. Exposure parameters for calculating clearance criteria for air samples.

Input Parameter	Value	Explanation
Risk	1 x 10^{-4}	See Appendix C
AT-(Averaging Time - Carcinogens) of LT	25,550 days	See Appendix D
ED (Exposure Duration)	30 years	Upper-bound Estimate of Time in Residence [EPA, 1989]
EF (Exposure Frequency)	365 days/yr	Days in Residence [EPA, 1989]
IUR (Inhalation Unit Risk)	2 3 E -01 (asbestos) 2.86 E +5 (dioxin)* 7.3 E 0 (PAHs)*	IRIS, 2002 Dioxin Reassessment, EPA, 2001 IRIS, 2002

*IUR was calculated by route-to-route extrapolation of oral Slope Factor

The cancer risk level ($1x10^{-4}$) employed herein reflects the upper bound of the acceptable risk range (10^{-4} to 10^{-6}) established in EPA's Superfund regulation [Federal Register, 1990]. Practical Quantitation Limits (PQLs, the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating procedures [EPA, 1992]) and anticipated background levels [ATSDR, 1995] dictated the selection of the risk level at $1x10^{-4}$ A more detailed discussion of this subject can be found in Appendix C.

For non-carcinogenic compounds, airborne contaminant concentration is compared to the Reference Concentration (RfC). The RfC is an estimate of a chronic exposure concentration for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime [EPA, 1989]. That comparison (i.e, chronic exposure concentration (CEC) divided by the RfC) is called the Hazard Quotient (HQ).

$$HQ = CEC/RfC$$

where CEC is the daily averaged air concentration, calculated as: AC * [EF*ED/AT-NC], where AC is the average air concentration during the period of exposure ($\mu g/m^3$), EF is the exposure frequency (days), ED is exposure duration (years), AT-NC is the averaging time for non-carcinogens, and RfC is the reference concentration, expressed in units of 1/concentration.

According to EPA guidelines [EPA, 1989], if the HQ is greater than one, there may be concern for potential health effects. Therefore, for Tier III (clearance level), the benchmark screening level was set at an HQ of 1. For Tier I, which equates to a sub-chronic exposure scenario, an HQ of 10 was used, in accordance with EPA's Hazard Evaluation Handbook [EPA, 1997]. An HQ of 10 accounts for the fact that chronic toxicity criteria (RfDs/RfCs) are being applied to sub-chronic exposure scenarios (i.e., exposure not expected to exceed 6 months to one year in duration) Accordingly, an HQ of 10 was used for non-carcinogens to reflect a similar (i.e., upper bound of 1 year) exposure duration. Note that contaminants (both non-carcinogens and carcinogens, alike) can exhibit acute effects from short-term, high-dose exposures. Because the Tier I benchmark levels are based on subchronic exposure (i.e., 1 year), acute effects from exposures that are below the benchmark levels would be unlikely. A review of EPA's draft Acute Exposure Guideline Levels [EPA, 2001a] and California EPA's (CAL-EPA) Acute Risk Levels demonstrates that the benchmark levels developed herein are categorically more stringent than the analogous US EPA and Cal-EPA acute levels.

Developing Risk-Based Criteria for Settled Dust

There is no established national guidance, and limited scientific literature, for assessing risk from interior surface wipe sampling (i.e., mass per unit area) data . The approach used in this report was adapted and modified from a methodology developed by the EPA Region III Superfund Program It has been employed by the U S. Army Corps of Engineers to develop risk-based clean-up goals for interior surfaces at the Claremont Polychemical Superfund site in Region II [Radian, 1999] Additionally, the methodology is similar to an approach employed by the NYSDOH for evaluating a dioxin contaminated office building [NYSDOH, 1985] and one previously proposed by NJDEP for setting interior building surface clean-up goals [NJDEP, 1993].

A full discussion of the methodology employed for developing risk-based benchmarks based on contact with residues on indoor surfaces is presented in Appendix D. Briefly, this methodology provides an estimate of daily dose resulting from dermal absorption and ingestion associated with contacting contaminated surfaces and hand-to-mouth transfers Dose is obtained by estimating the following: skin contact area and contact frequency with contaminated surfaces, transfer efficiency between surface and hand, transfer efficiency between hand and mouth, oral absorption of the contaminant and dermal absorption of residual contamination on skin. Consistent with the approach for indoor air, toxicity criteria were obtained from IRIS. The assessment procedure is described briefly below and in more detail in Appendix D.

For the purpose of developing risk-based clearance levels for interior surfaces, this approach is preferable to an approach that relies on measuring contaminant concentration on a mass per mass (ppm) basis (as might be done for an exterior soil assessment). After cleaning has occurred, it would be difficult to obtain the mass of dust necessary to perform a mass per mass measurement of contaminant concentration. In addition, literature on interior lead contamination demonstrates a strong correlation between lead load (mass per unit area) and blood lead concentration in children (Lanphear et. al., 1998).

The following table lists the input parameters and numerical values (along with a brief explanation) used in this procedure (See Appendix D for equations and a more detailed discussion.)

Table 3. Exposure parameters used to calculate clearance criteria for wipe samples.

Input Parameter	Value	Explanation
SA (Skin Surface Area)	400 cm^2	Palm Side of Hands
CF (Contact Frequency)	16/day	See Appendix D
FTSS (Fraction Transferred from Surface to Skin)	0.05	See Appendix D
EF (Exposure Frequency)	365 days/yr	Days in Residence [EPA, 1989]
ED (Exposure Duration)	30 years	Upper-bound Estimate of Time in Residence [EPA, 1989]
ABSo (Oral Absorption Fraction)	1	See Appendix D
FTSM (Fraction Transferred from Skin to Mouth)	0.1	See Appendix D
ABSd (Dermal Absorption Fraction)	0.03 (dioxin) 0.13 (PAHs)	Chemical Specific [EPA, 2001b]
BW (Body Weight)	70 kg	Average Adult [EPA, 1989]
AT-NC (Averaging Time - Non Carcinogen)	–	
AT-C (Averaging Time - Carcinogen)	25,550 days	See Appendix D
CSF (Cancer slope factor -dermal and oral)	1.0 E+6 (dioxin) 7 3 E 0 (PAHs)	Dioxin Reassessment: EPA, 2001 IRIS, 2002

In light of the limited data for many of the input parameters used to estimate dose from exposure to residues on surfaces, conservative exposure estimates were employed. Still, there may be a concern for highly exposed sub-populations. Infants and young children constitute such a group due to age-specific activities such as crawling and mouthing and increased surface-area to body-weight ratios. In cases where non-carcinogenic effects are driving clearance levels, the difference in dose on a mg/kg/day basis between an adult and a young child could be considerable. However, in this document the two compounds (dioxin, PAHs) for which the surface contact methodology has been used to develop clearance levels are carcinogens, so it is this effect that drives the clearance levels. As such, the Tier III clearance level is strongly influenced by overall exposure duration, which in this assessment has been set at 30 years. Consequently, weighted over 30 years, the impact of a high-exposure period (i.e., early childhood) is diluted It is acknowledged that Tier I (one year exposure duration) screening levels for carcinogens may underestimate cancer risk for children, but Tier I contaminant levels are not expected to persist, therefore the magnitude of any associated uncertainty would be small. If a contaminant was to be added to the COPC list that had its clearance level based on a non-carcinogenic endpoint, a separate wipe assessment analysis should be performed taking into account childhood exposure parameters. A more complete discussion of the uncertainties associated with the methodology for surface contact assessment is presented in Appendix D.

With the exception of asbestos, the extremely limited air sampling data for specific building constituents in indoor air dictated that an assessment approach had to be based on historical data relating the concentration of fibers in air (fibers per cubic centimeters or f/cc) to the load in settled dust (fibers per square centimeters or f/cm^2) [Millette and Hays 1994]. Although the empirical relationships (called K factors) are not rigorous enough to rely on for a firm health decision, they are used in this report to define what might constitute elevated building material counts that would need to be addressed on a near-term basis. This approach may overestimate potential exposures but, as such, is protective

Developing Benchmark Levels Based on Occupational Health Standards

For fibrous glass and silica, risk-based methods were not available for indoor air due to lack of established environmental toxicity criteria. Therefore, benchmark levels were set based on occupational health standards established by the American Conference of Governmental Industrial Hygienists [ACGIH] (called "threshold limit values" or TLVs) and the Occupational Safety and Health Administration [OSHA] (called "permissible exposure limits" or PELs). TLVs/PELs are established to protect employees who might have been exposed to substances during an eight-hour day, for five days a week. For Tier I levels, TLVs/PELs were divided by ten to be more protective of residents who might be exposed to substances twenty-four hours a day, seven days a week. In addition, the TLVs/PELs were established to protect a healthy worker. For Tier III levels, TLVs or PELs were divided by 100 to be protective of a more diverse population that includes sensitive individuals such as children, older adults, and the infirm.

The following tables show the benchmark levels developed for each contaminant of potential concern. Each table is accompanied by risk equations, toxicity criteria and a summary of any contaminant-specific assumptions that were made in developing the benchmark values.

Table 4. Lead

Tier	Action	Lead (settled dust)		Lead (indoor air)	
		Level	**Basis**	**Level**	**Basis**
I	Aggressive cleaning If levels persist, take additional action to reduce exposure.	>40 ug/ft^2	1) HUD standard for floors 2) Residential Lead Hazard Standard (TSCA Section 403)	>1 5 ug/m^3	NAAQS (intended to keep 99 5% of children below 30 ug/dl)
II	Maintain recommended cleaning methods Consider additional monitoring	40 ug/ft^2 to 25 ug/ft^2 (or background)	25 ug/ft^2 is HUD screening level for floors	1.5 ug/m^3 to 1 ug/m^3 (or background)	1 ug/m^3 is the calculated value using EPA's IEUBK Lead Model for Children*
III	No further action	<25 ug/ft^2 (or background)	Level could also be set at that found in background, or unaffected, areas, so that no increase in risk due to lead would be expected	1 ug/m^3 (or background)	Level could also be set at that found in background, or unaffected, areas, so that no increase in risk due to lead would be expected.

* EPA developed the Integrated Exposure Uptake Biokinetic (IEUBK) Lead Model [EPA, 1994] to evaluate multimedia lead exposure to children in residential settings. EPA established a goal of attaining a 95% probability that blood lead levels in children be less than 10 ug/dl [EPA 1994a]. Setting the indoor air lead concentration at 1 ug/m^3 (and using background concentrations for lead in water, diet, soil and dust) the IEUBK Lead Model estimates that 96% of the blood lead probability distribution falls below 10 ug/dl See Appendix E for model run data files and graph of blood lead probability distribution

Table 5. Polycyclic Aromatic Hydrocarbons (PAHs)

Tier	Action	PAHs (settled dust)		PAHs (indoor air)	
		Level	Basis	Level	Basis
I	Aggressive cleaning If levels persist, take additional action to reduce exposure	>9 mg/m^2	9 mg/m^2 represents a $1x10^{-4}$ risk estimate for a 1 year exposure	>6 ug/m^3	6 ug/m^3 represents a $1x10^{-4}$ risk estimate for a 1 year exposure
II	Maintain recommended cleaning methods. Consider additional monitoring	9 mg/m^2 to 0.3 mg/m^2 (or background)	0 3 mg/m^2 represents a $1x10^{-4}$ risk estimate for a 30 year exposure	6 ug/m^3 to 0 2 ug/m^3 (or background)	0 2 ug/m^3 represents a $1x10^{-4}$ risk estimate for a 30 year exposure
III	No further action	<0 3 mg/m^2 (or background)	Level could also be set at that found in background, or unaffected, areas, so that no increase in risk due to PAHs would be expected.	<0.2 ug/m^3 (or background)	Level could also be set at that found in background, or unaffected, areas, so that no increase in risk due to PAHs would be expected

Toxicity criteria for benzo(a)pyrene:

Oral Slope Factor = 7.3 E 00 $(mg/kg/day)^{-1}$ (IRIS, 2002)

(Inhalation cancer risk was calculated by route-to- route extrapolation of oral Slope Factor)

The following carcinogenic PAHs are evaluated as benzo(a)pyrene-equivalents [EPA, 1993]:

Compound	Relative Potency
Benzo(a)pyrene	1
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0 01
Chrysene	0.001
Dibenzo(a,h)anthracene	1
Indeno(1,2,3-c,d)pyrene	0.1

Table 6. Dioxin

Tier	Action	Dioxin (settled dust)		Dioxin (indoor air)	
		Level	Basis	Level	Basis
I	Aggressive cleaning. If levels persist, take additional action to reduce exposure.	>120 ng/m^2	120 ng/m^2 represents a 1×10^{-4} risk estimate for a 1 year exposure	>0 03 ng/m^3	0.03 ng/m^3 represents a 1×10^{-4} risk estimate for a 1 year exposure
II	Maintain recommended cleaning methods Consider additional monitoring	120 ng/m^2 to 4 ng/m^2 (or background)	4 ng/m^2 represents a 1×10^{-4} risk estimate for a 30 year exposure	0.03 ng/m^3 to 0 001 ng/m^3 (or background)	0 001 ng/m^3 represents a 1×10^{-4} risk estimate for a 30 year exposure
III	No further action	<4 ng/m^2 (or background)	Level could also be set at that found in background, or unaffected, areas, so that no increase in risk due to dioxin would be expected	<0.001 ng/m^3 (or background)	Level could also be set at that found in background, or unaffected, areas, so that no increase in risk due to dioxin would be expected

Toxicity criteria for dioxin:

Oral Slope Factor = 1.0 E 06 (mg/kg/day)$^{-1}$ [EPA, 2001]

(Inhalation cancer risk was calculated by route-to- route extrapolation of oral Slope Factor)

The table above reflects the proposed cancer Slope Factor for 2,3,7,8 TCDD and the toxicity equivalence (TEQ) paradigm for carcinogenic dioxin/furan congeners present in EPA's draft dioxin reassessment [EPA, 2001]. An equivalent table reflecting the previous IRIS-verified cancer Slope Factor for 2,3,7,8 TCDD would be represented by multiplying all listed values by a factor of six.

The methodology for estimating dose from wipe sampling data (see Appendix D) is consistent with the approach NYSDOH used in assessing office buildings in Binghamton, with modifications made to input parameters to reflect residential rather than occupational exposure. In addition, the Tier III benchmark equates to a lifetime exposure level which is approximately one tenth of that which results from current dietary intake of dioxin (65 pg/d). It is thus reasonable to assume that any lower level of exposure would result in an inconsequential reduction in the current risk levels experienced by the general U.S. population.

Information regarding NYC background levels also would be an important consideration in determining the appropriate longer-term value. This report proposes selecting the longer-term value on the basis of a 1×10^{-4} risk level or NYC background, as determined by the WTC-directed Background Study

Table 7. Asbestos

Tier	Action	Asbestos (Settled Dust)		Asbestos (indoor air)	
		Level	Basis	Level	Basis
I	Aggressive cleaning. If levels persist, take additional action to reduce exposure. Evaluate conditions in the area, including representativeness of air samples, asbestos settled dust levels, and loading	> 30,000 f/cm^2	Millette's K factor to estimate airborne levels for different activities (see narrative below)	>0.028 f/cc (PCME*)	0 028 f/cc represents a 1×10^{-4} risk estimate for a 1 year exposure
II	Maintain recommended cleaning methods. Consider additional monitoring. Evaluate conditions in the area including representativeness of air samples, fibrous glass settled dust levels and loading	30,000 f/cm^2 to background	---	0.028 f/cc 0 0009 f/cc (or background)	0.0009 f/cc represents a 1×10^{-4} risk estimate for a 30 year exposure
III	No further action required.	Background	Level is set at that found in background, or unaffected, areas, so that no increase in risk due to the asbestos fibers would be expected	0 0009 f/cc (PCME*) (or background)	Level is set at that found in background, or unaffected, areas In this way, no increase in risk due to the asbestos fibers would be expected

* PCME - fibers greater than 5 micrometers long (aspect ratio >3:1). Analysis by TEM

Toxicity criteria for asbestos:

Inhalation Unit Risk = 2.3 E-01 $(f/cc)^{-1}$ [IRIS, 2002]

Risk-based criteria were used to develop the Tiered benchmark levels for asbestos in air. Conservative assumptions of continuous exposure to a constant level of airborne fibers for either 1 year (Tier I) or 30 years (Tier III) were combined with the IRIS Slope Factor to establish benchmarks representative of a 1x 10-4 estimate of excess lifetime cancer risk for each scenario This approach makes several assumptions, chief among those is the quantification of asbestos fibers in air based on the PCM definition of a fiber (greater than 5um in length with an aspect ratio of 3:1 or greater) and the use of the IRIS Slope Factor which was designed to apply to fibers so defined. Although there is some concern regarding shorter fibers, the approach used here represents the current consensus by the US EPA for quantifying risk of airborne asbestos fibers. It should be noted there is ongoing debate regarding the nature of health effects which may be attributed to shorter asbestos fibers Both EPA and ATSDR are currently pursuing meetings to discuss and further refine these issues. However for the purposes of this response, addressing PCM equivalent fibers is considered protective.

The Tier I level for asbestos in settled dust was based on K factors [Millette and Hays, 1994], which are empirical relationships between concentrations of asbestos fibers in settled dust and indoor air Millette developed the K factors by studying matched air and settled dust samples taken from various homes, at varying levels of activity in the home. The Tier I level was based on the K factor for a worst case scenario of a high level of activity. Although K factors are not rigorous enough to rely upon for a firm health decision, they are used here only to define what might constitute elevated fiber counts, that would need to be addressed as a near-term concern This approach may overestimate potential exposures, but as such, is protective.

It should be noted that the airborne Tier I level of 0.028 f/cc PCM equivalents roughly equates to the AHERA TEM standard of 70 f/mm^2 (0.022 f/cc) in total fiber counts. Based on empirical information from the WTC ambient air monitoring program [EPA, 2002c] that recorded less than 20% of total AHERA TEM fiber counts to be >5 um in length, the AHERA TEM standard of 70 f/mm^2 (0.022 f/cc) and the alternate AHERA PCM standard of 0.01 f/cc both meet the risk-based criteria established for the Tier I screening level.

Table 8 Fibrous Glass

Tier	Action	Fibrous Glass (settled dust)		Fibrous Glass (indoor air)	
		Level	Basis	Level	Basis
I	Aggressive cleaning If levels persist, take additional action to reduce exposure Evaluate conditions in the area including representativeness of air samples, fibrous glass settled dust levels and loading	> 100,000 f/cm^2	Millette's K factor to estimate airborne levels for different activities (see narrative below)	> 0.1 f/cc	ACGIH TLV of 1 f/cc (see narrative below)
II	Maintain recommended cleaning methods. Consider additional monitoring Evaluate conditions in the area including representativeness of air samples, fibrous glass settled dust levels and loading.	100,000 f/cm^2 to background	---	0 01 to 0.1 f/cc	---
III	No further action required	background	Level is set at that found in background, or unaffected, areas In this way, no increase in risk due to the fibers would be expected	< 0 01 f/cc	ACGIH TLV of 1 f/cc (see narrative below)

* Fibers with length > 5µm with an aspect ratio > 3:1, as defined in the ACGIH TLV
Air concentrations measured by PCM, NIOSH 7400, confirmed by SEM.

The benchmarks for airborne fibrous glass were set based on the consideration that low level exposures to fibrous glass would not pose the potential for significant long-term health effects given the expected low biopersistence of these materials [ATSDR, 2002]. The current occupational exposure standards for fibrous glass (glass and mineral wools) is established to prevent the upper respiratory tract and skin irritant effects. In order to apply this standard to a general population and accounting for a longer daily exposure than seen in the occupation setting, uncertainty factors were used to reduce the allowable airborne levels for the Tiered bench marks. The Tier I benchmark is set at one tenth of the TLV and the Tier III level is set at 1 hundredth of the TLV. It is believed these levels will prevent conditions which may cause irritant health effects for most individual.

Although fibrous glass in settled dust is known to be a contact irritant, little data exist to provide a threshold relating to what fiber loading may result in skin irritation, or airborne levels of concern However, as with asbestos it was deemed preferable to have a Tier I benchmark available so that there was some upper bound to settled dust loadings that may trigger action. Here again Millet's K factors were used to correlate dust loading levels to the air benchmarks. The Tier I level for fibrous glass in settled dust was based on Millette's K factors, which are empirical relationships between concentrations of asbestos fibers in settled dust and indoor air. Millette developed the K factors by studying matched air and settled dust samples taken from various homes, at varying levels of activity in the home. The Tier I level was based on the K factor for a worst case scenario of a high level of activity. Although K factors are based on activity data for asbestos, they are believed to be protective for fibrous glass, which is larger and less airborne. In addition, although K factors are not rigorous enough to rely upon for a firm health decision, they are used here only to define what might constitute elevated fiber counts, that would need to be addressed as a near-term concern. This approach may overestimate potential exposures, but as such, is protective.

The Tier I level for fibrous glass in indoor air was based on the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit value (TLV) of 1 f/cc. That TLV is based on limiting irritant effects of fibrous glass on workers The TLV was divided by a factor of ten to account for the different exposure durations between ACGIH's workers and the WTC area's residents

The Tier III level for fibrous glass in indoor air was based on the ACGIH TLV of 1 f/cc, divided by a factor of 100 to account for greater exposure and the different sensitivities between ACGIH's healthy works and the WTC area's more varied population

Table 9 Crystalline silica - respirable fraction of alpha-quartz

Tier	Action	Crystalline Silica (settled dust)		Crystalline Silica (indoor air)	
		Level	Basis	Level	Basis
I	Aggressive cleaning If levels persist, take additional action to reduce exposure. Evaluate conditions in the area including representativeness of air samples, asbestos settled dust levels and loading	---	---	10 0 $\mu g/m^3$ *	OSHA PEL of 100 $\mu g/m^3$ (see narrative below)
II	Maintain recommended cleaning methods. Consider additional monitoring. Evaluate conditions in the area including representativeness of air samples, fibrous glass settled dust levels and loading.	above background		10.0 $\mu g/m^3$ to 1 $\mu g/m^3$ (or background) *	
III	No further action required.	background	Level is set at that found in background, or unaffected, areas In this way, no increase in risk due to the silica in settled dust would be expected	1 $\mu g/m^3$ or background	OSHA PEL of 100 $\mu g/m^3$ (see narrative below)

* Silica measured in airborne respirable dust, by NIOSH 7500.

The benchmarks for silica in indoor air were derived from the Occupational Safety and Health Administration's (OSHA) permissible exposure limit (PEL) for dust containing 100% respirable silica in air of 100 $\mu g/m^3$ (0.1mg/m^3)as a time weighted average for an 8 hour exposure.

Silica exposure poses risk of both cancer and non-cancer respiratory health effects. Although no

Reference Concentration (RfC) or IRIS Slope Factor exists, there are methodologies for examining risks of non-occupational exposures, on which to draw upon for a risk based approach to set benchmark levels. The approach taken here is a dual approach, where in the face of uncertainties the quantification of the benchmarks was based on the current occupational standards. Broader risk-based discussion of other methodologies provides support for the chosen benchmark levels although not quantitatively employed here to derive the benchmarks.

The Tier I benchmark is set at one tenth of the OSHA PEL. A single year of exposure at this benchmark (10ug/m^3) would provide a cumulative silica loading to the lungs less than the 1mg/m^3 work-year loading which is believed to be the departure point for adverse health effects Additionally this level is also the effective National Ambient Air Quality Standard for silica, where PM_{10} at 50 ug/m^3 contains no more than 10% crystalline silica. A recent review by supports the finding that this level would be protective of long-term non-cancer health effects [EPA, 1996]. The Tier III benchmark is set at one hundredth of the OSHA PEL. A 30 year continuous exposure at this level would not result in a cumulative silica loading to the lungs greater than the 1mg/m^3 year loading which is believed to be the departure point for adverse health effects.

References

Agency for Toxic Substances and Disease Registry. 1995. Toxicological Profile for Asbestos. U.S. Dept. of Health and Human Services, Atlanta, GA
http://www atsdr.cdc.gov/toxprofiles/tp61.html

Agency for Toxic Substances and Disease Registry. 2002. Technical Briefing Paper· Health Effects from Exposure to Fibrous Glass, Rock Wool or Slag Wool. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Atlanta, GA.
http://www.atsdr cdc.gov/DT/fibrous_glass_061402.pdf

Chatfield EJ, Kominsky JR. 2001 Characterization of Particulate Found in Apartments After Destruction of the World Trade Center. Summary Report Prepared for Ground Zero Elected Officials Task Force, New York.
http://www eqm.com

Federal Register 3/8/90. EPA - National Contingency Plan 40 CFR Part 300.
http://www.epa.gov/superfund/contacts/newmisc htm

International Agency for Research on Cancer (IARC). 1988. Monograph on Man-made Mineral Fibers, Vol 43, p. 39. *In*: IARC Monographs of the Evaluation of Carcinogenic Risks to Humans. International Agency for Research on Cancer, World Health Organization, Lyon, France
http://www.iarc.fr/

Integrated Risk Information System (IRIS) 2002 USEPA, Office of Research and Development. Available on line at:
http.//www epa.gov/iris

Johnson C. 2002. Mercury Vapor Levels in Dwellings in Close Proximity to the WTC Site. City University of New York.
Electronic link not available

Lanphear B.P., Matte T.D., Rogers J , et al. 1998. The Contribution of Lead-Contaminated House Dust and Residential Soil to Children's Blood Lead Levels. Environ Res: (79) 51-68
http://www.idealibrary.com/links/doi/10.1006/enrs.1998.3859

Lioy, P., et al. 2002. Characterization of the Dust/Smoke Aerosol that Settled East of the World Trade Center (WTC) in Lower Manhattan after the Collapse of the WTC September 11, 2001. EHP, Vol 110 (7) P. 703 - 714.
http://157.98 13.103/members/2002/110p703-714lioy/lioy-full.html

Millette J.R., Hays S.M 1994 Settled Asbestos Dust Sampling and Analysis. CRC Press Boca Raton, FL.
Electronic link not available

New Jersey Department of Environmental Protection. 1993. Technical Basis and Background for Cleanup Standards for Contaminated Sites. N.J.A.C. 7:26D (Draft).

New York City Department of Health and Agency for Toxic Substances and Disease Registry 2002. Final Technical Report of the Public Health Investigation to Assess Potential Exposures to Airborne and Settled Surface Dust in Residential Areas of Lower Manhattan. Atlanta: US Department of Health and Human Services.
Electronic link not available

New York State Department of Health 1985 PCB Re-Entry Guidelines. New York State Department of Health, Bureau of Toxic Substances Assessment, Division of Environmental Health Assessment Albany, NY. July 17. Document 1330P.
Electronic link not available

Radian International. 1999. Development of Risk-Based Wipe Sample Cleanup Levels at the Claremont Polychemical Superfund Site in Old Bethpage, New York. Prepared for: U.S. Army Corps of Engineers.
Electronic link not available

Rottner, B R. 2002. Special Technical Report: Occupational and Environmental Exposures to Mercury at the World Trade Center Emergency Project. New York City Department of Design and Construction.
Electronic link not available

U.S Department of Health and Human Services. 2001 Public Health Service National Toxicology Program, 9th Report on Carcinogens, Revised January.
http://157.98.13.104/roc/toc9 html

U.S. Environmental Protection Agency (EPA). 1989 Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A). OSWER, EPA/540/1-89/002.
http://www.epa.gov/superfund/programs/risk/ragsa/index.htm

U.S. Environmental Protection Agency (EPA). 1992. Guidance for Data Usability in Risk Assessment (Part A). OSWER. 9285.7-09A.
http://www epa.gov/superfund/programs/risk/datause/parta htm

U.S Environmental Protection Agency (EPA). 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. Office of Research and Development. EPA/600/R-93/089.
http://www.epa.gov/cgi-bin/claritgw?op-Display&document=clserv:epa-cinn:4308;&rank=4&template=epa

U.S. Environmental Protection Agency (EPA). 1994. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children.

http://www.epa.gov/superfund/programs/lead/ieubk htm

U S Environmental Protection Agency (EPA). 1994a. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. OSWER 9355.4-12
http://www.epa gov/superfund/programs/lead/

U.S. Environmental Protection Agency (EPA). 1996. Ambient Levels and Noncancer Health Effects of Inhaled Crystalline and Amorphous Silica· Health Issue Assessment. EPA/600/R-95/115.
http //www.epa.gov/ncea/pdfs/0604 pdf

U.S. Environmental Protection Agency (EPA), Region III. 1997 Hazard Evaluation Handbook A Guide to Removal Actions. EPA 903/B-97-006.
Electronic link not available

U.S. Environmental Protection Agency (EPA) 2001. Exposure and Human Health Re-assessment of 2,3,7,8- Tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds. Office of Research and Development. Peer Review Draft.
http·//cfpub1.epa.gov/ncea/cfm/dioxreass.cfm?ActType=default

U.S Environmental Protection Agency (EPA). 2001a. Acute Exposure Guideline Levels (Peer Review Draft) OPPTS, Wash. D.C.
Electronic link not available

U.S. Environmental Protection Agency (EPA). 2001b. Risk Assessment Guidance for Superfund Volume 1· Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim EPA/540/R/99/005. Review Draft.
http://www.epa gov/superfund/programs/risk/ragse/index htm

U.S. Environmental Protection Agency (EPA). 2002a. Special Investigative Audit #14: Environmental Data Trend Report, World Trade Center Disaster; Final Update - Trends for Data Collected 9/11/01 to 4/24/02 from Lower Manhattan. Prepared by IT Corporation for Office of Emergency and Remedial Response.
http://www.nycosh.org/WTCdraft2_102901.pdf - (Draft Version - October 2001)

U.S. Environmental Protection Agency (EPA). 2002b Toxicological effects of fine particulate matter derived from the destruction of the World Trade Center, April 2002 draft National Health and Environmental Effects Research Laboratory, Office of Research and Development.
http://www epa gov/ORD/scienceforum/air_abstracts/gavett pdf

U.S. Environmental Protection Agency (EPA). 2002c EPA Website for World Trade Center Sampling Results.
http://www.epa.gov/wtc

U.S. Geological Survey (2001) Environmental Studies of the World Trade Center after the

September 11, 2001 Attack. Open File Report OFR-010429.
http://greenwood cr usgs.gov/pub/open-file-reports/ofr-01-0429/

Wallace, Deborah. 1990. In the Mouth of the Dragon: Toxic Fires in the Age of Plastics Avery Publishing Group, Inc., New York
Electronic link not available

APPENDIX A
Hazardous Substances Not Included in Indoor Environment Sampling Program

Benzene

Benzene is a volatile organic chemical (VOC) that was found in emissions from the open flames and smoldering debris left after the collapse of the WTC The benzene may have originated from the airplanes' residual jet fuel or from the continuous burning of plastics and other materials contained within the collapsed towers

Since the fires and smoldering debris persisted long after the collapse of the WTC towers, there is a possibility that harmful levels of benzene vapor could have accumulated in nearby indoor environments. However, because benzene is very volatile and dissipates into ambient air quickly, the vapor plumes would have had to contain high concentrations of benzene, and the indoor area would have had to be relatively close to the fire source in order for indoor amounts of benzene to build up to harmful levels. In addition, unlike dioxin, benzene cannot become adsorbed by dust particles and transported indoors to settle as a long-term potential hazard. Once the source of the benzene is extinguished completely from the area, then benzene will dissipate and will not be a hazard.

Results of samples taken *within* the immediate WTC work zone from September 11 through mid-January 2002, show benzene levels of up to 180,000 parts per billion (ppb). However, tests during the same time period *outside* the work zone show levels of benzene that were below the established EPA screening level of 20 ppb for the ambient air (see Appendix B), indicating how quickly benzene dissipates in the air A specific example, for the day of October 3, is shown below:

From debris pile at WTC North Tower	From debris pile at WTC South Tower	From Liberty & Greenwich Streets
28,000-39,000 ppb	4,300 ppb	less than 20 ppb

From January 26 through April 23, 2002 (the most recent test date available) levels of benzene in ambient air have remained below the 20 ppb screening level, except for one grab sample from the immediate work zone on February 9 and another sample from the same location on February 12. These tests indicate that the source of harmful ambient benzene levels has been extinguished, and therefore there is no source of benzene available to accumulate in any indoor environment Benzene will not be monitored in any further indoor environment testing.

Polychlorinated Biphenyls (PCBs)

PCBs were historically used as coolants and lubricants in transformers, capacitors, and other electrical equipment. It is possible that, with the WTC collapse, PCBs could have been dispersed into the ambient air and then transported indoors. However, in well over 500 ambient air samples taken around the WTC site, no measurements were found above EPA's screening level of 730 ng/m^3 in the ambient air (see Appendix B). This indicates that PCBs in ambient air are not considered to be at harmful levels, therefore, PCBs will not be monitored in indoor environment testing.

Chromium

Chromium is a naturally occurring element commonly used in metal alloys and plumbing coatings in high rise buildings such as the WTC. Chromium and its compounds can be found in air as very fine dust particles that eventually settle over land, and can cause cancer and other health problems if inhaled at high concentrations. To date, in over 300 air samples, levels of chromium measured in ambient air around the WTC work zone have all been below EPA's screening level of 0.6 ug/m^3 in the ambient air (see Appendix B). Measurements in settled dust [EPA 2002c, Lioy 2002] have been below EPA Removal Action Guidelines [EPA, 1997]. Because of these low values, chromium is not being considered a hazard at the WTC site Therefore, chromium will not be monitored in any indoor environment testing.

Cadmium and Manganese

Cadmium and manganese, both hazardous air pollutants, were detected in some ambient air samples taken at the WTC site. However, in over 300 samples, cadmium was found in only two samples at levels over EPA's screening level of 0.2 ug/m^3 in the ambient air (see Appendix B). In over 300 samples, manganese was found in only four samples at levels above EPA's screening value of 0.5 ug/m^3 in the ambient air (see Appendix B) Because of the low ambient concentrations of these two metals, they will not be monitored in any indoor environment testing

Mercury

In late December 2001, it was reported that four New York City Port Authority police officers were tested with elevated levels of mercury in their blood This raised concerns over the air quality at the WTC area. The officers were retested under medical surveillance to determine whether the source of mercury was the air over the WTC. The retesting found that the levels of mercury in the officers' blood and urine were below levels of concern established by NYCDOH and the American Conference of Governmental Industrial Hygienists The cause of the first elevated mercury levels is not known, but may be from something that the officers had eaten the day before the blood tests were done, and not WTC air. In fact, Rottner [2002] has reported only one mercury air sample above detection limits to date in the WTC area.

In addition, data from a U.S. Geological Survey leachability study [USGS, 2001] performed on both indoor and outdoor WTC dust samples found mercury in leachate samples only at trace levels (up to 18 parts per trillion [ppt] for outdoor dust and 130 ppt in indoor dust) Because only trace levels of mercury appear to be present in indoor dust samples, the probability that harmful levels could ever be released to the air is very low. Therefore, mercury will not be monitored in any further indoor environment testing

Particulate Matter

Particulate Matter (as fine dust and smoke) in the 10 micron and smaller size range is inhalable and may cause throat and lung irritation Because of the energy released by the WTC disaster, dust containing particulate matter in this size range was generated. If this dust had not been able to settle, or if there had remained a continuous source of particulates being released into the ambient air, then there would have been a concern that hazardous dust could infiltrate nearby homes and offices. However, ambient monitoring for fine particulate matter in the WTC area has shown that, since late October, the levels of PM 10 (inhalable dust fraction 10 microns and smaller) and PM 2.5 (respirable fraction 2.5 microns and smaller) have been below the levels of concern:

PM10	150 ug/m3	NAAQS 24-hour average
PM2.5	65 ug/m3	NAAQS 24-hour average
	40 ug/m3	Air Quality Index, 24-hour average (moderate impact)

This indicates that there is no continuing concern of hazardous fine particulate matter entering homes and offices in the WTC area. Therefore, particulate matter will not be monitored in any further indoor environment testing.

Refractory Ceramic Fibers (RCF)

Ceramic fibers are reasonably anticipated to be human carcinogens based on sufficient evidence of carcinogenicity in experimental animals [IARC V.43, 1988]. When administered by inhalation, rats of both sexes showed a significant increase in the incidence of benign and malignant tumors of the lung However, there are no data available to evaluate the carcinogenicity of ceramic fibers in humans [IARC V 43, 1988]

It is not expected that ceramic fiber-containing materials were present in large quantities in the WTC buildings, since those materials are used mainly in industrial high temperature applications.

Some air sampling has been performed for ceramic fibers in a recently completed study by ATSDR and NYCDOH [NYCDOH, 2002]. During the period from November 4 through December 11, 2001, environmental samples were collected in 30 buildings in lower Manhattan and four locations above 59th Street. Settled dust samples were taken both indoors and out, and analyzed for asbestos and other fibers by PLM. Although fibrous glass was reported in many settled dust samples, RCF was not reported as a fiber present by PLM. Air samples, also taken in these areas, were analyzed for fibers by PCM. Six of these study area air samples appeared to contain fiber levels in air higher than the levels found above 59th Street. Four of the samples from areas containing fibrous glass in settled dust were re-analyzed by SEM and were not found to contain any ceramic fibers above the detection limit (0.00004 f/cc).

Even though this is a limited study, it appears to confirm limited to no use of ceramic fibers in the WTC buildings. Therefore, ceramic fibers will not be monitored in any further indoor environment testing

Mold

Mold was not generated during the WTC collapse or associated fires. However, mold may be present because of actions taken in response to the collapse Substantial quantities of water were used to extinguish the fires and to wash buildings affected by the collapse. Some of that water entered buildings, causing indoor mold contamination. Additionally, the loss of electric power after the collapse affected the ability of buildings' ventilation and plumbing systems to control indoor environments. This may have contributed to indoor mold contamination in some buildings.

The most common symptoms of exposure to mold are runny nose, eye irritation, cough, congestion, and aggravation of asthma. Although there is evidence documenting severe health effects of mold in humans, most of this evidence is derived from eating mold-contaminated foods, or occupational exposures in agricultural settings, where inhalation exposures were very high. There are no numeric standards to define "safe" levels of mold. In addition, it is very unlikely that the existence of mold in buildings around the WTC site can be distinguished from mold conditions existing prior to the attack. Therefore, the guidance established below is qualitative in nature and targeted towards detecting the presence of mold and removing it, rather than quantifying levels that pose health risks

When inspecting a building, investigators should:

1. Look for evidence of visible mold or water damage throughout the apartment or office. Pay particular attention to moldy odors

2 Ask the building management if water damage was noted as a result of the WTC attack or events thereafter The investigator should be alert for situations where the loss of power to a building may have created a situation where either the ventilation or plumbing systems failed or leaked, creating water damage.

3 If mold contamination is encountered, it should be removed in accordance with New York City Department of Health mold removal guidelines:

http://www.nyc gov/health/html/doh/html/epi/moldrpt1 html

APPENDIX B
World Trade Center Health Effects Screening Criteria for Ambient Air

Introduction

Extensive air quality monitoring data have been collected at and around the World Trade Center (WTC) site since 9/11/01. Table 1 (Screening Criteria) is intended to provide health protective screening values for data evaluation Analysis has been performed on an extensive list of potentially WTC-related contaminants. Many of the chemicals screened have demonstrated a consistently low (i.e., below detection limits or trace amounts) trend. Consequently, the list of contaminants in Table 1 represents those chemicals that, because of their intrinsic toxicity and frequency/magnitude-of -detection, pose the greatest potential hazard from exposure. This selection process (i.e., a toxicity/concentration analysis), although qualitative, reflects the *contaminant-of-concern identification process recommended in the Risk Assessment Guidance* for Superfund. Table 1 may be expanded as additional data analysis becomes available. Two populations have been identified for assessment response/demolition (i.e., WTC site) workers; and residents living in Lower Manhattan (e.g., Battery Park City, Tribeca and other residential locations close to Ground Zero). Included in the resident category are all other workers located in Lower Manhattan with the exception of WTC site workers.

Relevant Standards

The following paradigm has been employed to develop screening values. For each of the two identified receptor populations (i.e., site workers and residents), existing standards are utilized where appropriate Occupational standards (i.e., OSHA PELs) are used for all site workers conducting response/demolition activities covered by OSHA. Monitoring data from demolition areas are compared to OSHA PELs. (For example, the OSHA PEL of 1 ppm for benzene is used to evaluate benzene air samples taken directly from within the plume on the debris pile.) Environmental standards (e g., NAAQS, AHERA) are utilized to evaluate monitoring data from the site perimeter and beyond where residents or non-WTC site workers may be exposed. (For example, lead air monitoring data from perimeter stations outside of the immediate work zone are evaluated against the NAAQS of 1.5 ug/m3.)

Risk-Based Screening Criteria

In cases where appropriate standards do not exist, risk-based screening criteria have been developed for residential (including the non-WTC site workers) receptors. (In the absence of *OSHA standards, it is beyond the scope of EPA's mission to develop "occupational" screening* values.) The risk assessment paradigm detailed in EPA's "Hazard Evaluation Handbook: A Guide to Removal Actions" (HEH) was employed for this initiative (except where otherwise noted in the Table 1 footnotes). Screening levels reflect the most current toxicity criteria (Slope Factors and RfCs) on EPA's IRIS database.

For carcinogenic compounds excess lifetime cancer risk was set at E-04 (one-in-ten thousand). The residential exposure scenario in the HEH was modified for carcinogens from the default of 30 years (upper-bound estimate for residency in one dwelling) to 1 year (to reflect an upper bound estimate for the length of time a resident may be potentially exposed to WTC-related contaminants). In cases where the screening value based on a noncancer endpoint is more stringent, screening values for both cancer and noncancer endpoints are presented. It is also noted that the default 30 year exposure duration (and the 1 year site-specific adjustment) reflects an apportionment between child (20% of total exposure duration) and adult (80 % of total exposure duration) receptors. Because children have comparatively greater (as a function of body weight) respiration rates than adults, the screening values presented in Table 1 are marginally more stringent than values that would otherwise be derived by direct application of IRIS verified Unit Risk values.

For noncarcinogenic compounds, the Hazard Quotient (chronic daily intake/RfC) was set at 10. A Hazard Quotient of 10 is employed in the HEH to account for the fact that chronic toxicity criteria (RfDs/RfCs) are being applied to sub-chronic exposure scenarios that are not expected to exceed 6 months - 1 year in duration. Accordingly, a Hazard Quotient of 10 was utilized for non-carcinogens in Table 1 to reflect a similar (i.e., upper bound of 1 year) exposure duration It is noted that contaminants (both non-carcinogens and carcinogens, alike) can exhibit acute effects from short-term, high-dose exposures. Because the screening values in Table 1 are based on subchronic exposure (i.e., 1 year), acute effects from exposures that are below the screening levels would be unlikely. Additionally, a review of California EPA's (CAL-EPA) Acute Risk Levels demonstrates that the screening criteria in Table 1 are categorically more stringent than the Cal-EPA's analogous acute levels.

NOTE: Individual sampling results that exceed screening values should not be interpreted to represent the occurrence of an adverse health effect. Rather, such information indicates the need for careful monitoring and the assessment of longer-term data trends for evaluation against appropriate health criteria. That is, most of the screening levels have been developed to account for continuous one year average exposure durations. Because these screening levels assume continuous exposure for an extended duration, the average of the measured concentrations is more appropriate for evaluating risk than an individual measurement. Consequently, miscellaneous individual values above the screening level may not necessarily be indicative of potential for concern

Table 1
World Trade Center Screening Criteria

Contaminant	Site Worker (1)	Resident (2)
Inorganics		
Asbestos (3)	.1 f/cc (PCM)	70 S/mm2 (TEM)
Cadmium	5 ug/m3	.2 ug/m3 (9) 3 ug/m3 (5)
Chromium (4)	100 ug/m3	.6 ug/m3 (5)
Lead	50 ug/m3	1.5 ug/m3 (7)

Contaminant	Site Worker [1]	Resident [2]
Manganese	5 mg/m3	.5 ug/3 [6]
Sulfur Dioxide	5 ppm	14 ppm [7]
<u>Particulates</u>		
Total	15,000 ug/m3	NA
Respirable	5,000 ug/m3	NA
$PM_{2.5}$	NA	40 ug/m3 [8] 65 ug/m3 [7]
PM_{10}	NA	150 ug/3 [7,8]
<u>Semivolatiles</u>		
Dioxin/Furans (TEQ)	NA	.162 ng/m3 [5]
PCBs	1,000 ug/m3	.73 ug/m3 [6] 9 ug/m3 [5]
PAHs [16]	NA	6 ug/m3 [5, 17]
<u>Volatiles</u>		
Acetone	1,000 ppm	1 5 ppm [6]
Benzaldehyde	NA	860 ppm
Benzene	1 ppm	.02 ppm [9] .21 ppm [5]
Benzonitrile	NA	NA
1,3 Butadiene	1 ppm	.01 ppm [5, 15]
Chloromethane	100 ppm	.4 ppm [6] 2.6 ppm [5]
1,4 Dioxane	100 ppm	.5 ppm [5]
Ethanol	1,000 ppm	45 ppm [10]
Ethylbenzene	100 ppm	2.5 ppm [6]
Freon 22	1,000 ppm [14]	140 ppm
Propylene	LEL [13]	simple asphyxiant
Styrene	100 ppm	2.3 ppm [6]

Contaminant	Site Worker [1]	Resident [2]
alpha methylstyrene	100 ppm	1 ppm [6]
Tetrahydrofuran	200 ppm	.9 ppm [5]
Toluene	200 ppm	1.1 ppm [6]
Xylenes	100 ppm	1 ppm [11]
Reactive Gases		
Acetaldehyde	200 ppm	.05 ppm [6] 1.3 ppm [5]
Formaldehyde	*.75 ppm*	*.04 ppm* [12] .35 ppm [5]
Acrolein	.1 ppm	.0001 ppm [6]

Units

f/cc = fibers (>5 um length) per cubic centimeter of air
S/mm2 = structures (>.5 um length) per square millimeter of filter paper
ppm = parts per million in air
ug/m3 = micrograms of contaminant per cubic meter of air
ng/m3 = nanograms of contaminant per cubic meter of air
NA - Not Applicable

Footnotes:

1. "Site Workers" refers to all workers involved in the response/demolition of the World Trade Center. Listed values are Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), Time Weighted Averages (TWA) unless otherwise noted.

2. "Residents" refers to people living in the vicinity of the World Trade Center as well as all other potentially exposed workers not involved in the response/demolition

3. Resident screening value is based on Asbestos Hazard Emergency Response Act (AHERA) methodology which uses transmission electron microscopy (TEM), and because of its basis in "background" (vs a risk basis) includes all asbestos fibers greater than 0.5 microns in length. Worker values are based on phase contrast microscopy (PCM, - which doesn't distinguish asbestos from other fibers) or, for results above the PCM screening value, TEM to derive a PCM equivalence that includes all asbestos fibers greater than 5 microns in length.

4. Screening values for chromium were based on the most toxic form (hexavalent)

5. EPA - Hazard Evaluation Handbook (HEH) (carcinogen) > 1 year of continuous exposure equating to an excess lifetime cancer risk of one-in ten thousand

6. EPA - HEH (noncarcinogen) > Hazard Quotient (HQ) = 10

7. National Ambient Air Quality Standard (NAAQS)
   - Lead is a 3 month average
   - $PM_{2.5}$ is a 24 hour average
   - Sulfur Dioxide is a 24 hour average primary standard

8. Air Quality Index (AQI)

9 Non cancer effects based on CAL-EPA toxicity studies

10. American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV)

11. Agency for Toxic Substances and Disease Registry (ATSDR) Inhalation minimum risk level (MRL) x 10

12. ATSDR acute MRL

13. Lower Explosive Limit (2 - 11 %)

14. National Institute of Occupational Safety and Health (NIOSH)

15 Proposed Reference Concentration (RfC) - HEH (noncancer) > Hazard Quotient (HQ) = 10

16. Based on Benzo(a)pyrene toxicity equivalency factor toxicity equivalency factor (TEF)

17. EPA National Center for Environmental Assessment (NCEA) provisional inhalation Slope Factor (3.1 E 00 mg/kg/day^{-1})

APPENDIX C
Basis for Tier III screening level of 1 E-04

Defensible analytical methodology and sampling protocols are being chosen for future indoor sampling and analysis activities. The methods chosen are ones that have been published by reputable agencies and are in common practice among testing laboratories. In some cases, minor modifications may be made to the sampling and analytical protocols, but these will be modifications that are well established in the laboratory community.

All protocols chosen are designed to reach the lowest level of detection that is reasonable for the established methods. For Dioxin, Asbestos and PAHs, the sampling and analytical protocols are designed to reach detection limits that represent risk estimate levels of 1 E-04. To reach risk estimates of 1E-06, extraordinary modifications would have to be employed. These modifications would either have to be incorporated into the analytical protocols to increase the sensitivity of the required instrumentation, incorporated into the sampling protocols to achieve a larger sample, or a combination of both. For the Chemical of Potential Concern (COPC) list, the analytical protocols chosen are already incorporating the maximum sensitivity of the instrumentation. Therefore, the only legitimate mechanism to lower the overall limits of detection is to modify the sampling protocol. The two means of achieving this goal are to either run the sampling equipment (pumps) at a higher flow rate, or for longer periods of time. For the COPC list modifying flow rates would involve operating the equipment to achieve flow rates on the order of 500 to 1000 liters per minute. The only equipment available to operate at such flow rates are large units that can not be brought inside a residence. Rates this high also present problems with creating excessive negative pressure for indoor environments, plus flow rates this high have not been tested using the sampling protocols, and there is high likelihood of having analyte breakthrough on the collection filters. Therefore, this is not practical. The other option is to run the equipment for long periods of time. Again with the list of Chemicals of Potential Concern, sampling periods of up to 800 hours (33 days of continuous operation) would be needed to reach the E-06 risk detection levels

For silica, the analytical and sampling protocols chosen will give detection levels in the neighborhood of 5 ug/m^3. Instrumental sensitivity can not be set any higher to reach lower detection levels. Also, the sampling protocols involved for this analysis have been thoroughly validated by NIOSH. Any change in pump flow rate or sampling duration beyond what is documented in the method will produce results that have not been validated. Therefore, the sampling protocol should not be changed from that which is documented.

For fibrous glass the methodology is such that detection levels as low as 0.00001 f/cc can be achieved This is well below required levels of detection for future indoor studies.

Another consideration in setting the target risk level involved the anticipated background level of contaminants such as asbestos, dioxin and PAHs in urban indoor environments As previously mentioned, EPA is currently conducting a study to characterize background conditions for WTC COPCs in New York City residential dwellings. In advance of this study, a literature review was conducted to provide a general estimate of background concentrations for carcinogenic COPCs in urban indoor environments. It should be noted that the literature is limited in this regard For asbestos, ATSDR reports that "measured indoor air values range widely, depending on the amount, type, and condition (friability) of asbestos-containing materials used in the building" [ATSDR, 1995]. In its review ATSDR notes that the studies suffer from lack of common measurement reporting units Study results have been reported as ng/m^3, f/cc (TEM) and f/cc (PCM). Using unit conversion factors recommended by the National Research Council in 1984, ATSDR [1995] reports that the arithmetic mean concentrations of monitoring data from a variety of indoor locations ranged from .00003 - .006 f/cc (PCM). The proposed clearance level for WTC-impacted residential dwellings (.0009 PCM equivalents) is within this background range.

APPENDIX D
Assessing Exposures to Indoor Air and to Residues on Indoor Surfaces

Introduction

The purpose of this Appendix is to provide further details on how procedures were selected to estimate exposure to indoor air and to residues on indoor surfaces in residences impacted by the WTC attack.

Indoor Air

Deriving clearance criteria for air samples was completed by using methods described in EPA's "Risk Assessment Guidance for Superfund" [RAGS, 1989]. These methods were developed to assess the risk from contaminants at Superfund sites. The clearance criteria were calculated using the formula below:

$$\textit{Clearance criteria} = (TR \times AT) / (ED \times EF \times IUR)$$

where

TR = Target Risk
AT = Averaging Time - Carcinogens
ED = Exposure Duration
EF = Exposure Frequency
IUR = Inhalation Unit Risk

<u>Target Risk</u>
The target risk identified for these calculations was 1 x 10-4 Appendix C explains the rationale for this value.

<u>Averaging Time - Carcinogens</u>
For non-carcinogens, AT is the exposure duration expressed in days. For carcinogens, exposure is averaged over a 70-year lifetime (the factor on which the cancer slope factors are based), and the AT is 70 years, in days (25,550).

<u>Exposure Duration</u>
A value of 30 years is assumed to match upper bound estimate of time in a residence (EPA, 1997b).

<u>Exposure Frequency</u>
A value of 365 days/year is used to represent a full time resident

<u>Inhalation Unit Risk</u>
The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air The interpretation of unit risk would be as follows if unit risk = 1.5×10^{-6} $\mu g/m^3$, 1 5 excess tumors are expected to develop per 1,000,000 people if exposed daily for a lifetime to 1 μg of the chemical in 1 cubic meter of air. The inhalation unit risk values used in the calculations are 2.3 E-01 for asbestos (IRIS, 2002), 2 86 E +05 for dioxin (Dioxin Reassessment, EPA, 2001), and 7 3 E+0 for PAHs (IRIS, 2002).

Residues on Indoor Surfaces

The most formal EPA guidance which addresses this issue is the "Standard Operating Procedures (SOPs) for Residential Exposure Assessment" originally published by the Office of Pesticides in 1997 and updated in 2001 (EPA, 1997a and EPA, 2001a). This guidance was designed for estimating exposures to pesticides. Pesticides are typically applied to indoor surfaces as liquid or sprayed formulations which would create surface residues which are likely to be somewhat different than the fine dust particles associated with the WTC attack. So while this guidance was considered, a number of other sources were also reviewed including the Superfund guidance on dermal contact (EPA,1989), the procedures used to develop re-entry guidelines for the Binghamton State Office Building (Kim and Hawley, 1985), procedures used by NJDEP for setting interior building surface clean-up goals (NJDEP, 1993), the building clean-up procedures presented by Michaud et al (1994) and an approach developed by the EPA Region III Superfund program that has been employed by the U.S. Army Corps of Engineers to develop risk-based clean-up goals for interior surfaces at the Claremont Polychemical Superfund site in Region II (Radian, 1999). Elements from these various methods were combined to derive the procedure shown below. The procedures involves 3 steps: 1) estimating the amount of chemical deposited on the skin using skin area, contact frequency and transfer efficiencies, 2) estimating the dermal dose based on an absorption fraction and 3) estimating the ingestion dose based on the fraction of material on hands that is transferred to the mouth.

1. Estimating Amount of Chemical Deposited on Skin

Ds = C x SA x CF x FTSS x EF x ED

Ds = Amount of chemical deposited on skin (mg)
C = Concentration of chemical on contaminated surface (mg/cm^2)
SA = Exposed skin surface area (cm^2)
CF = Contact frequency of skin against surface (1/day)
FTSS = Fraction transferred from surface to skin
EF = Exposure frequency (days/year)
ED = Exposure duration (years)

2. Estimating Dermal Dose

Dd = (Ds x (1 - FTSM) x ABSd) / (BW x AT)

Dd = Dermal dose (mg/kg/day)
FTSM = Fraction transferred from skin to mouth
ABSd = Dermal absorption fraction
BW = Body weight (kilograms)
AT = Averaging time (days)

3. Estimating Oral Dose

Do = (Ds x FTSM x ABSo) / (BW x AT)

Do =	Oral dose (mg/kg/day)	BW =	Body weight (kilograms)
FTSM =	Fraction transferred from skin to mouth	AT =	Averaging time (days)
ABSo =	Oral absorption fraction		

The surface concentration term (C) was assumed to remain constant over the entire 30 year exposure period. This is probably not true for surfaces in the residences impacted by the WTC attack. Surface loadings will decline as a result of volatilization, chemical degradation, surface cleaning and transfers to skin/clothing. While some redeposition will also occur, the net long term effect should be a gradual decline. In this sense, the method will overestimate exposures. This same issue has been recognized in similar assessments involving building clean-ups and pesticide exposures:

- Two scenarios were considered in developing the procedures used to develop re-entry guidelines for the Binghamton State Office Building (Kim and Hawley, 1985). One assumed a constant surface concentration and the other assumed a first order exponential decay
- The OPP guidance (EPA, 1997a and EPA, 2001a) uses a "dissipation" factor to account for degradation and other loss mechanisms after pesticide application. Similarly, Durkin et al (1995) has proposed a time-dependent transfer coefficient method for lawn treatment pesticides.
- Michaud et al (1994) proposed a mass balance model which accounts for losses from surfaces associated with building clean-ups.

Thus, while methods have been proposed to deal with changes in surface residue strength over time, it is uncertain how well these apply to the situation in residences near WTC. Thus for purposes of this screening assessment, it was decided to assume constant levels.

4. Calculating Clearance Criteria

In order to calculate a clearance criteria for wipe samples, the formulas identified above need to be rearranged to derive a concentration based on the target cancer risk or non-cancer hazard. The clearance criteria for settled dust, using a wipe sample, for each COPC can be calculated using the formula listed below and the exposure parameters listed in Table 3 in the body of the document.

Clearance criteria (mg/m2) = (TR x BW x AT) / [((Dd x CSFd) + (Do x CSFo)) x EF x ED]

The other terms in this procedure and associated uncertainties are discussed below:

<u>Exposed Skin Surface Area (SA)</u>

The skin surface area of 400 cm^2 is a typical value for the palm side of adult hands (EPA, 1997b) which is the body part that is most likely to contact surfaces.

<u>Contact Frequency (CF)</u>

Michaud et al (1994) assumed 8 contacts per day, apparently based on professional judgment. Low-end values of 1/day and "worst-case" rates of 24/day (3/hour) may be assumed as a matter of professional judgment; such exposure would obviously involve a very physical job with frequent contact with the walls and floor. The value recommended here is 16 contacts per day and is based on professional judgement. If available, site-specific activity data should take precedence.

Fraction Transferred from Surface to Skin (FTSS)
This will vary depending on type of surface, type of residual, hand condition, force of contact, etc Rodes et al 2001 conducted experiments on particle transfer to dry skin and measured transfers of 10% from carpets and 50% from hard surfaces. These transfer efficiencies were found to decline with repeated contacts. The OPP guidance recommends 5% of application rate for carpets and 10 % for hard surfaces (EPA, 1997a). USEPA has previously assumed transfer of 0.5 for PCBs (EPA, 1987) based on an Office of Toxic Substances (OTS) assessment. Michaud et al (1994) assumed 0.5 for PCBs and dioxins, but stated that 0.1 might be more realistic. In developing re-entry guidelines for the Binghamton State Office Building after a fire, a 100% transfer was assumed (Kim and Hawley, 1985). In a study of Malathion uptake from different surfaces, USEPA-EMSL found that FTSS of malathion from painted sheetrock to human hands was only 0.0003. (Mean transfer from vinyl flooring to hands was 0.0018, and from carpet to hands was 0.0152.) Malathion is a pesticide assumed to have lipophilicity more similar to PCBs than to volatiles or metals. However, the representativeness of such a number for PCBs and dioxins is unknown. PCBs are more lipophilic (have higher Kows) than malathion. A value of 5% is recommended here. Although this is on the low end of the literature values, when combined with the high contact frequency, it provides a fairly high total transfer to skin.

Exposure Frequency (EF)
A value of 365 days/year is used to represent a full time resident.

Exposure Duration (ED)
A value of 30 years is assumed to match upper bound estimate of time in a residence (EPA, 1997b)

Fraction Transferred from Skin to Mouth (FTSM)
Michaud et al (1994) assumed that all of the residues deposited on the fingertips would be transferred to the mouth, twice per day. A similar approach is used in the OPP guidelines. In the Binghamton re-entry guideline derivation, a range of factors were used. 0.05, 0 1, and 0.25 representing the fraction of residue on hand that is transferred to the mouth (Kim and Hawley, 1985). A similar value of 10% is recommended here.

Oral Absorption Fraction (ABSO)
For chemicals whose dose-response parameters are based on experiments in which the absorption fraction is similar to the one expected in the exposure scenario, there is no need to adjust the RfD or CSF.

Body Weight (BW)
A value of 70 kilograms is assumed which represents an average adult (EPA, 1997b).

Averaging Time (AT)
For non-carcinogens, AT is the exposure duration expressed in days. For carcinogens, exposure is averaged over a 70-year lifetime (the factor on which the cancer slope factors are based), and the AT is 70 years, in days (25,550).

Dermal Absorption Fraction (ABSd)
This parameter is chemical-specific. Dermal absorption fractions of 0 06 for PCBs and 0.03 for dioxins from soil were first proposed in USEPA, 1992 and more recently adopted in EPA 2001b. Michaud et al (1994) used 0.02 for dioxins and 0.03 for PCBs uptake from a sooty surface, based on the ranges of estimated ABSd values for soil. The Binghamton panel used a range of values for PCBs (0.01, 0.1, and 0.5) and dioxins (0.01 and 0.1) (Kim and Hawley, 1985).

Reported ranges for dermal uptake for PCBs in solvent vehicles are reported to range from 15 to 56%, with most of the values clustering around 20% (ATSDR, 1993). Reported ranges for 2,3,7,8-TCDD in solvent vehicles are reported to range from 1 to 40% (ATSDR, 1988). Therefore, it seems that even if absorption from the wall material might be enhanced by residual solvent, the maximum possible absorption of 100% would be unrealistic even for worst-case exposure.

The values recommended here of 3% for dioxins and 13% for PAHs are based on EPA, 2001b.

Toxicity Values
There are two toxicity values that can be used to calculate screening values, a Reference Dose (RfD) for non-carcinogenic compounds and a Cancer Slope Factor (CSF) for carcinogenic compounds. The RfD is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used. The CSF is defined as an upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg/day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100 As the cancer endpoint was more sensitive, CSFs were used instead of RfDs. The CSFs used to calculate the clearance criteria are: 1.0 E+6 for dioxin (Dioxin Reassessment, EPA, 2001) and 7.3 E+0 for PAHs (IRIS, 2002).

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1988. Toxicological Profile for 2,3,7,8-Tetrachlorodibenzo-p-dioxin. United States Public Health Service, ATSDR, Atlanta, GA.

ATSDR 1993. Toxicological Profile Update for Polychlorinated Biphenyls. United States Public Health Service, ATSDR, Atlanta, GA.

Durkin, P.R., L. Rubin, J. Withey, and W. Meylan. 1995. Methods of assessing dermal absorption with emphasis on uptake from contaminated vegetation. Toxicology and Industrial Health 11(1):63-79.

Kim N K and J. Hawley. *1985.* Re-Entry Guidelines: Binghamton *State Office Building.* New York State Dept. of Health, Bureau of Toxic Substances Assessment, Division of Health Risk Control. Albany, NY. August. Document 0549P.

EPA. 1987. Polychlorinated Biphenyls: Spill Cleanup Policy. Final Rule. Federal Register, Volume 52, Number 63. April 2.

EPA. 1989. Risk Assessment Guidance for Superfund Volume I· Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.

EPA. 1992. Dermal Exposure Assessment: Principles and Applications. Interim Report. Office of Health and Environmental Assessment, Washington, D.C. January EPA/600/891/011/B

EPA, 1997a. Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessment Office of Pesticides Programs. December 19, 1997.

EPA, 1997b. Exposure Factors Handbook. EPA/600/P95/002

EPA, 2001a. Science Advisory Council for Exposure. Policy Number 12 on Recommended Revisions to the Standard Operating Procedures (SOPs) for Residential Exposure Assessments Revised: February 22, 2001

EPA, 2001b. Risk Assessment Guidance for Superfund Volume 1. Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005. Review Draft

Michaud, J M , S.L Huntley, R A. Sherer, M.N. Gray, and D.J. Paustenbach 1994. PCB and dioxin re-entry criteria for building surfaces and air. Journal of Exposure Analysis and Environmental Epidemiology 4(2):197-227.

New Jersey Department of Environmental Protection (NJDEP) 1993. Technical Basis and

Background for Cleanup Standards for Contaminated Sites. N.J.A.C. 7:26D (Draft).

Radian International. 1999. Development of risk-based wipe sample cleanup levels at the Claremont Polychemical Superfund site in Old Bethpage, New York. Prepared for: U.S. Army Corps of Engineers.

Rodes, C., R. Newsome, R Vanderpool, J Antley, R Lewis. 2001. Experimental methodologies and preliminary transfer factor data for estimation of dermal exposure to particles Journal of Exposure Analysis and Environmental Epidemiology, 11.123-139.

APPENDIX E
IEUBK Model Results for Lead in Air

LEAD MODEL FOR WINDOWS Version 1.0 Build 251

Model Version: 1.0 Build 251
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration. 100.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	0.000	2.000	32.000	1 000
1-2	0.000	3.000	32.000	1.000
2-3	0.000	5.000	32.000	1.000
3-4	0 000	5.000	32.000	1 000
4-5	0.000	5.000	32.000	1 000
5-6	0.000	7 000	32 000	1.000
6-7	0.000	7.000	32.000	1 000

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	5.530
1-2	5.780
2-3	6.490
3-4	6.240
4-5	6.010
5-6	6.340
6-7	7.000

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0 520
3-4	0.530
4-5	0.550
5-6	0 580
6-7	0 590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 240.000 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor. 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100 000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	200.000	240.000
1-2	200.000	240.000
2-3	200.000	240.000
3-4	200.000	240.000
4-5	200.000	240.000
5-6	200.000	240 000
6-7	200 000	240.000

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0 000
4-5	0 000
5-6	0.000
6-7	0.000

****** Maternal Contribution· Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

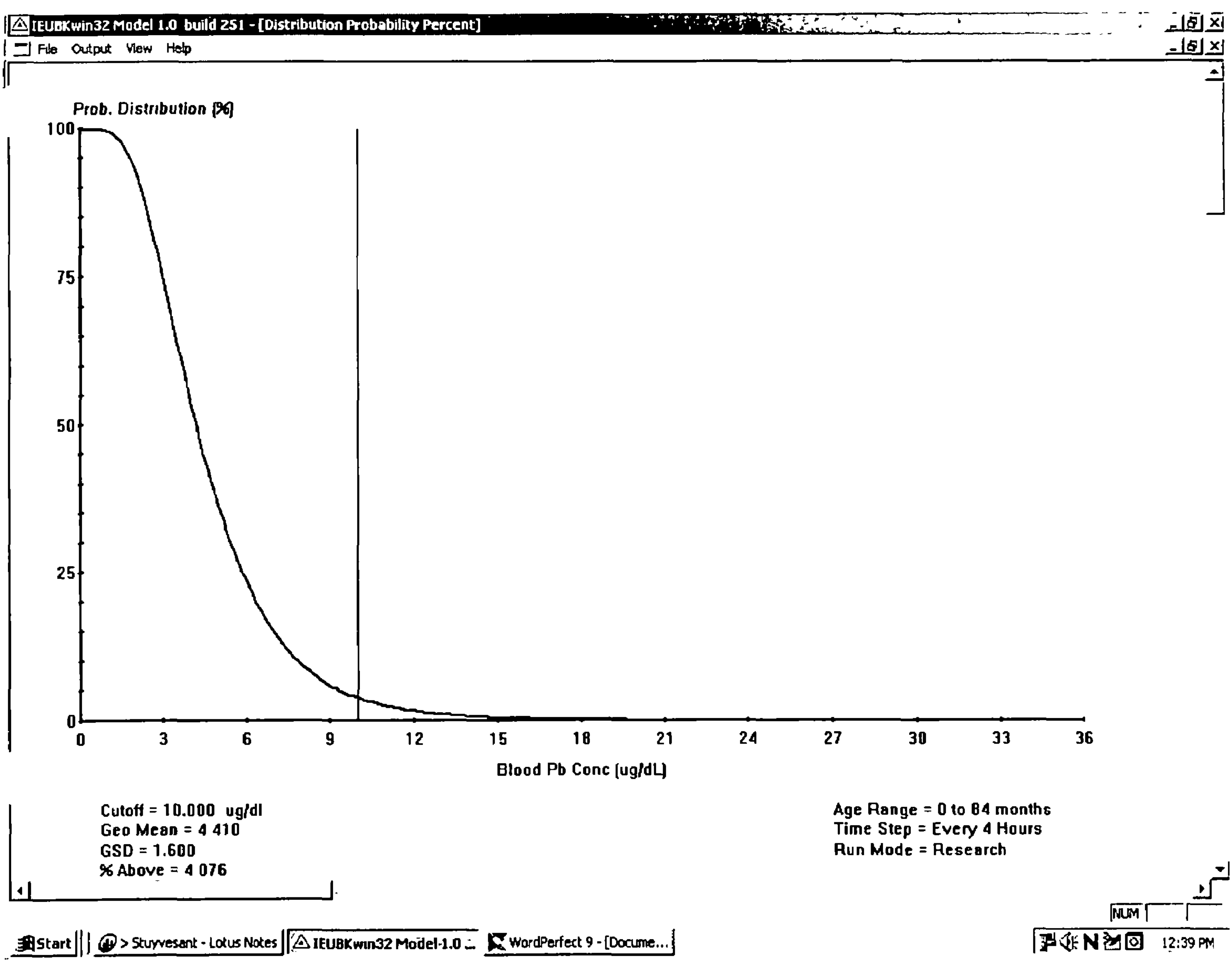
****

CALCULATED BLOOD LEAD AND LEAD UPTAKES·

****

Year	Air (ug/dL)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0 640	2.521	0.000	0 365
1-2	0.960	2 608	0.000	0.902
2-3	1.600	2.963	0.000	0.950
3-4	1.600	2.886	0.000	0.981
4-5	1.600	2.842	0.000	1 040
5-6	2.240	3 022	0.000	1.106
6-7	2.240	3.349	0.000	1.129

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	5 162	8 688	4.7
1-2	8.113	12.583	5.2
2-3	8.210	13.723	5 0
3-4	8 318	13.785	4.8
4-5	6.298	11.780	4 1
5-6	5.714	12.081	3.7
6-7	5.417	12.135	3.5


IEUBKwin32 Model 1.0 build 251 - [Distribution Probability Percent]
File Output View Help
Prob. Distribution (%)
100
75
50
25
0
0 3 6 9 12 15 18 21 24 27 30 33 36
Blood Pb Conc (ug/dL)
Cutoff = 10.000 ug/dl
Geo Mean = 4 410
GSD = 1.600
% Above = 4 076
Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research
NUM
Start
> Stuyvesant - Lotus Notes
IEUBKwin32 Model-1.0
WordPerfect 9 - [Docume...
12:39 PM

B

ATTACHMENT B

DATA VALIDATION
STANDARD OPERATING PROCEDURES

The following SOPs were used by the Quality Assurance Technical Support Contractor for the validation of analytical data:

SOP QATS-70-077-01	THE DATA VALIDATION OF TRANSMISSION ELECTRON MICROSCOPY (TEM) DATA PACKAGES GENERATED USING ASTM METHOD 5755-95 (Dec. 17, 2002)
SOP QATS-70-078-01	THE DATA VALIDATION OF PHASE CONTRAST MICROSCOPY (PCM) DATA PACKAGES GENERATED USING NIOSH METHOD 7400 (Dec. 17, 2002)
SOP QATS-70-076-01	THE DATA VALIDATION OF TRANSMISSION ELECTRON MICROSCOPY (TEM) DATA PACKAGES GENERATED USING EPA 40 CFR, PART 763, SUBPART E (Dec. 17, 2002)
SOP QATS-70-075-01	THE DATA VALIDATION OF INORGANIC METALS DATA PACKAGES GENERATED USING EPA METHOD 6010B AND EPA METHOD 7471A (Dec. 17, 2002)
SOP QATS-70-074-01	THE DATA VALIDATION OF HRGC/HRMS DATA PACKAGES GENERATED USING EPA METHOD 8290 (Dec. 17, 2002)
SOP QATS-70-073-02	VALIDATING SILICA DATA GENERATED BY METHOD MSD 0700 X-RAY DIFFRACTION (XRD) (Dec. 17, 2002)
SOP QATS-70-071-01	THE DATA VALIDATION OF TRANSMISSION ELECTRON MICROSCOPY (TEM) DATA PACKAGES GENERATED USING ASTM METHOD D 6480-99 (Dec. 17, 2002)
SOP QATS-70-072-01	THE DATA VALIDATION OF POLYNUCLEAR AROMATIC HYDROCARBON (PAH) WIPE SAMPLE DATA PACKAGES GENERATED USING EPA METHOD 8270C (MODIFIED) (Dec. 17, 2002)
SOP QATS-70-070-01	THE DATA VALIDATION OF MAN-MADE VITREOUS FIBERS/MMVF) DATA PACKAGES BY POLARIZED LIGHT MICROSCOPY (PLM) AND SCANNING ELECTRON MICROSCOPY (SEM) GENERATED USING MSD 0310

C

ATTACHMENT C

EMSL ANALYSIS
STANDARD OPERATING PROCEDURES

The following SOPs were used by the contracted laboratory, EMSL for the analysis of Man-Made Vitreous Fibers (MMVF) and Silica:

EMSL MSD 0310	OPERATING PROCEDURE FOR THE ANALYSIS OF MAN-MADE VITREOUS FIBERS FOR THE EPA RESIDENTIAL SAMPLING PROJECT (Feb 2002, Modified Mar 2002)
EMSL MSD 0700	OPERATING PROCEDURE FOR THE ANALYSIS OF SILICA (α-quartz, cristobalite or tridymite) BY X-RAY DIFFRACTION FOR THE EPA RESIDENTIAL SAMPLING PROJECT

ATTACHMENT D

SAMPLING AND ANALYTICAL METHODS

1. NIOSH Method 7400: *Asbestos and Other Fibers by PCM*; NIOSH Manual of Analytical Methods; U.S. Department of Health and Human Services, National Institute of Occupational Safety and Health: Washington, DC, 1994.

2 AHERA Asbestos-Containing Materials in Schools. *Code of Federal Regulations*, Part 763, Title 40, 2001.

3 EMSL MSD 0300: *Material Science Division Operating Procedures for Man-Made Vitreous Fiber ID*; EMSL Analytical, Inc., NY, 2001.

4. NIOSH Method 7300: *Elements by ICP*, NIOSH Manual of Analytical Methods; U.S. Department of Health and Human Services, National Institute of Occupational Safety and Health. Washington, DC, 1994.

5 EPA SW-846 6010B: *Inductively Coupled Plasma-Atomic Emission Spectrometry*, Test Methods for Evaluating Solid Wastes Physical/Chemical Methods; U.S. Environmental Protection Agency, Office of Solid Waste: Washington, DC, 1996.

6 NIOSH Method 7500. *Silica, Crystalline, by XRD*, NIOSH Manual of Analytical Methods, U.S. Department of Health and Human Services, National Institute of Occupational Safety and Health: Washington, DC, 1998.

7. ASTM Standard D 5755-95: *Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentrations*; American Society for Testing and Materials· West Conshohocken, PA, 2001.

8. ASTM Standard E 1973-99. *Standard Practice for Collection of Surface Dust by Air Sampling Pump Vacuum Technique for Subsequent Lead Determination*, American Society for Testing and Materials: West Conshohocken, PA, 2001

9 ASTM Standard D 6480-99. *Standard Test Method for Wipe Sampling of Surfaces, Indirect Preparation, and Analysis for Asbestos Structure Number Concentration by Transmission Electron Microscopy*, American Society for Testing and Materials: West Conshohocken, PA, 2001

10 ASTM Standard D 6661-01 *Standard Practice for Field Collection of Organic Compounds from Surfaces Using Wipe Sampling*; American Society for Testing and Materials: West Conshohocken, PA, 2001.

11. EPA SW-846 8290: *Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS)*; Test Methods for Evaluating Solid Wastes Physical/Chemical Methods; U S. Environmental Protection Agency, Office of Solid Waste: Washington, DC, 1994

12. EPA SW-846 8270C: *Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)*, Test Methods for Evaluating Solid Wastes Physical/Chemical Methods; U S. Environmental Protection Agency, Office of Solid Waste: Washington, DC, 1996.

13. *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing*, U.S. Department of Housing and Urban Development Washington, DC, 1995; *Appendix 13 1 Wipe Sampling for Settled Lead-Contaminated Dust.*

14. NYSDOH Method 198.1: *Polarized-Light Microscope Methods for Identifying and Quantitating Asbestos in Bulk Samples*; New York State Department of Health, Environmental Laboratory Approval Program: Albany, NY, 1997

15 NYSDOH Method 198.4: *Transmission Electron Microscope Methods for Identifying and Quantitating Asbestos in Non-Friable Organically Bound Bulk Samples*; New York State Department of Health, Environmental Laboratory Approval Program. Albany, NY, 1997.

E

ATTACHMENT E

Photographs of Sample Collection Activities

Photo 1: Residential Air Sampling Set up and Operation

Photo 2: Common Space Air Sampling Set up and Operation with co-located duplicate samples

Photo 3: Calibration of Air Sampling Pumps

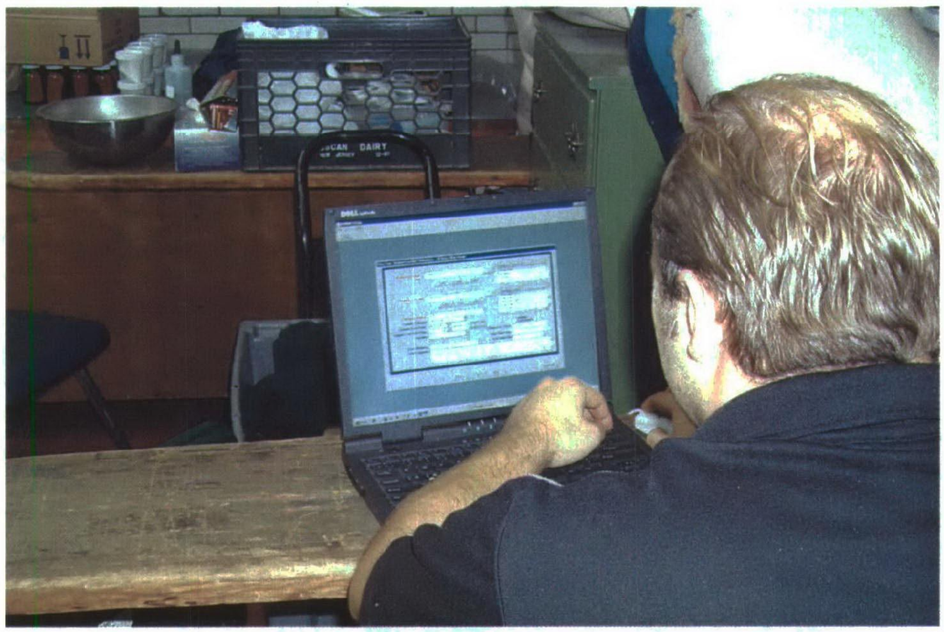


Photo 4: Use of FORMS II *Lite*™ in the field for generation of sample labels, chain of custody, and sample management.

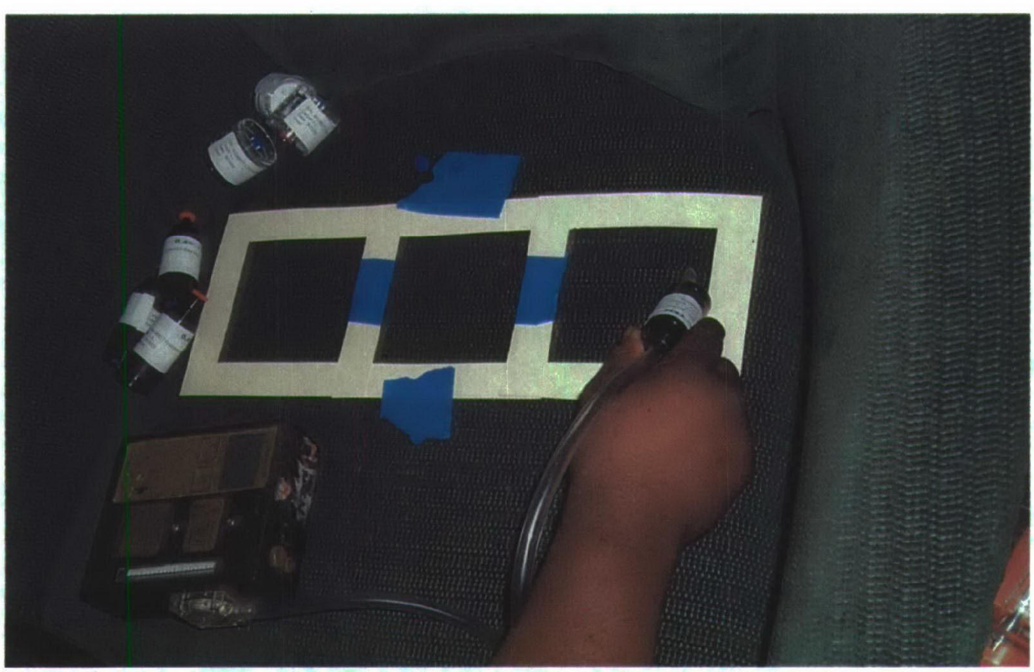


Photo 5: Collection of Microvacuum Samples on fabric furniture.

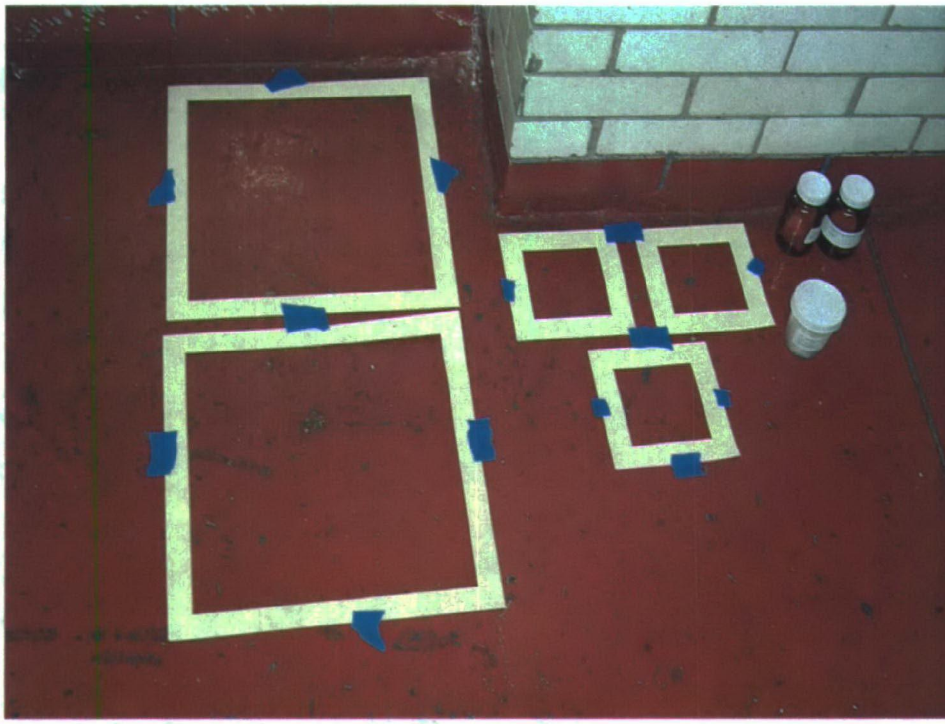


Photo 6: Common Space Floor Wipe Template Set up

Photo 7: Residential Wall Wipe Sampling

Photo 8: Counter Wipe Sampling of a Common Space

ATTACHMENT F

National Institute of Standards & Technology - Certificate of Analysis, Standard Reference Material 2581

Appendix 14.3: Procedure for the Preparation of Field Spiked Wipe Samples of the Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing.

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2581

Powdered Paint
Nominal 0.5 % Lead

This Standard Reference Material (SRM) is intended for use in the evaluation of methods and for the calibration of apparatus used to determine lead in paint SRM 2581 is composed of paint collected from the interior surfaces of housing A unit consists of 35 g of powdered paint material, 99+ % of which passes a 100 μm (No 145) sieve The certified mass fraction of lead, given below, is based on measurements by isotope dilution inductively coupled plasma mass spectrometry (ID-ICPMS) with a minimum sample size of 100 mg The certified value is reported on a dry basis (see Instructions for Drying)

Certified Mass Fraction

Lead Content 0 449 % ± 0 011 %

The uncertainty in the certified value is calculated as

$$U = ku_c$$

where u_c is the combined standard uncertainty calculated according to the ISO Guide [1] and k is a coverage factor The value of u_c is intended to represent at the level of one standard deviation, the combined effect of uncertainty components associated with material inhomogeneity and ID-ICPMS measurement uncertainty In the absence of Type B uncertainties (which are negligible here in comparison with Type A), the expanded uncertainty (U) given is for a 95 % prediction interval The coverage factor, k = 2 57, is the Student's t-value for a 95 % prediction interval with 5 degrees of freedom

NOTICE AND WARNING TO USERS

Expiration of Certification: The certification of this SRM lot is valid within the measurement uncertainties specified until December 31, 2010, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see Use) However, the certification will be nullified if the SRM is contaminated or modified

Stability: This material is considered to be stable NIST will monitor this material and will report any substantial changes in certification to the purchaser Return of the attached registration card will facilitate notification

Use: To relate analytical determinations to the certified value on this Certificate of Analysis, a minimum sample mass of 100 mg should be used and the sample should be dried according to the Instructions for Drying Sample preparation procedures should also be designed to effect complete dissolution in order to relate the determined value to the certified value This SRM must be stored in an air conditioned environment or similar cool and dry environment away from sunlight and fumes

The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program by B S MacDonald

The overall direction and coordination of the technical measurements leading to certification of this SRM were performed by J R DeVoe, P A Pella, and R L Watters, Jr of the NIST Analytical Chemistry Division

Statistical consultation was provided by S D Leigh of the NIST Statistical Engineering Division

Partial financial support for the development of this SRM was provided by the U S Environmental Protection Agency (EPA) under the direction of project managers S L Harper and M E Beard of the EPA Office of Research and Development, National Exposure Research Laboratory, Research Triangle Park, NC

COLLECTION, PREPARATION, AND ANALYSIS

Collection: The paint material for this SRM was collected primarily in North Carolina from various interior wall surfaces of old housing which, for the most part, were painted prior to 1945 The material was collected under the direction of the Research Triangle Institute and the U S Environmental Protection Agency Collection of paint by dry scraping and its initial evaluation for use as SRM 2581 were performed by J D Neefus, E E Williams, and D B Binstock, of the Research Triangle Institute, Research Triangle Park, NC, under the leadership of W F Gutknecht

Preparation: The largest pieces of debris and foreign material were first removed by hand Next, the material was coarsely chipped in a large-capacity blender fitted with a stainless steel blade The material was then further ground in small batches in a ball mill Each batch was sieved and the fraction that did not pass a 100 µm (#145) sieve was returned for further grinding with a fresh charge of coarse paint material All material of a size less than 100 µm was combined and blended as a single batch before being bottled in 35 g units

Analysis: Certification analysis by ID-ICPMS was performed by E S Beary and K E Murphy of the NIST Analytical Chemistry Division X-ray fluorescence homogeneity analysis was performed by A F Marlow and P A Pella and inductively coupled plasma-optical emission spectrometric (ICP-OES) analysis was performed by L J Wood of the NIST Analytical Chemistry Division

The ICP-OES analysis data given in Table 1 provide information on the concentrations of major constituents other than lead in the material These values listed are not certified, but are given only to provide additional information on the matrix

Instructions for Drying: Samples of this SRM should be dried in an air atmosphere at 105 °C for 2 h At NIST, loss on drying according to this procedure was about 1 % relative by mass However, under different conditions of humidity, the mass loss could vary In order for users to directly relate their analyses to the certified value, loss on drying corrections should be measured and applied at the time of the analysis

Environmental Lead Proficiency Analytical Testing Program Results: This material was included as an unknown in the Environmental Lead Proficiency Analytical Testing Program (ELPAT) administered by the American Industrial Hygiene Association (AIHA) Conventional dissolution methods employed by participating laboratories include hotplate, microwave, and other techniques such as sealed bomb dissolutions and leaching techniques Instrumental determinations were performed using inductively coupled plasma mass spectrometry (ICPMS), inductively coupled plasma-optical emission spectrometry (ICP-OES), flame atomic absorption spectrometry (FAAS), graphite furnace atomic absorption spectrometry (GFAAS) and X-ray fluorescence spectrometry (XRF) Information from this study is provided to indicate the state of the practice for lead in paint measurements using such methods A summary of the round robin lead results obtained from ELPAT Reference Laboratories for SRM 2581 is presented in Table 2 The SRM 2581 is identified as round robin 015, paint #3 in the ELPAT report

SUPPLEMENTAL INFORMATION

Table 1 Information Values for Major Constituents of SRM 2581

Element	Mass Fraction (%)
Al	2
Ca	11
Fe	0 4
Mg	1
Ti	12
Zn	2

Table 2 Environmental Lead Proficiency Analytical Testing (ELPAT) Program
Summary Statistics of Reference Laboratories for Round Robin 015[a]

Sample	n	Mean	Minimum	Maximum	s^b		
Paint 3	80	0 417 %	0 349 %	0 470 %	0 030		

[a]These results are provided to demonstrate user experience with this material They were not used in calculating the certified value of SRM 2581
[b]s is one standard deviation

REFERENCE

[1] *Guide to the Expression of Uncertainty in Measurement*, ISBN 92-67-10188-9, 1st Ed, ISO, Geneva, Switzerland, (1993) See also Taylor, B N and Kuyatt, C E, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," NIST Technical Note 1297, U S Government Printing Office, Washington, D C, (1994)

Appendix 14.3: Procedure for the Preparation of Field Spiked Wipe Samples

There is currently no analytical grade wipe media suitable for wipe sampling in residences. A variety of commercial media are being used instead (see Appendix 13 1). Because laboratory accreditation programs do not currently provide spiked wipe samples using wipe sampling media commonly used in the field, it is necessary to prepare spiked wipe samples using the specific brand of wet wipes that will actually be used in order to determine if the laboratory digestion procedure is capable of achieving recovery rates between 80 - 120% for the specific brand of diaper wipe used in the field. Some reports indicate that recovery rates can be as low as 40% using certain types of wipes.

These field spiked samples are in addition to those the laboratory prepares for its own internal QA/QC program. The samples are not actually prepared in the field, but are manufactured under laboratory conditions. They are then relabelled in the field and inserted into the sample stream in a random and blind fashion. The spikes should be prepared using the same lot as that used in the field, since recoveries can vary by lot The lot should be analyzed before use to ensure that there is not background contamination.

The following procedure may be used to prepare spiked wipe samples.

1 Obtain a Standard Reference Material containing a certified concentration of lead, such as NIST Standard 1579a (Powdered Lead-Based Paint) or Standard 1648 (Urban Particulate), or a traceable secondary standard with a known amount of lead.

2. Weigh out between 50 - 500 µg of lead (not total dust) to the nearest microgram.

3 Don a new disposable glove to handle each new wipe sample.

4 If tared weighing boats are used, quantitatively transfer all of the material from the boat to the wipe by wiping the boat thoroughly.

5. If glassine paper is used, be certain that the dust transfer was complete.

6 Do not let the wipe touch any other surface Fold the wipe with the spiked side inward and carefully insert it into a non-sterilized 50 ml centrifuge tube or other hard-shelled container that is identical to the containers that will hold the field samples. The containers holding the spiked samples should be indistinguishable from those holding the field samples so that the analysis can be performed blindly This means the same container or tube should be used to hold field samples and wipe samples.

7 Have the spiked sample inserted into the sample stream randomly, with at least one spiked sample for each 50 field samples analyzed and one blank for each sample batch.